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OBSERVATIONS OF THE CHANGES OF COLOUR AND MODES OF TAKING FOOD IN THE CHAMELEON.

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The chameleon has ever been an object of curiosity, and in the times of great ignorance of natural history it was a special subject of wonder, as well as of much fable, in consequence of its frequent and unaccountable changes of colour, and its supposed faculty of living without food: its only diet being the air, of which it drew within itself a large abundance, and from which it was believed to acquire a considerable increase of size. But its habits in these respects were differently represented, even by those who appeared to be careful observers; and it was therefore with much pleasure that I had an opportunity of observing them in an example which was presented to me, and which was embarked on board of a ship at Cadiz, with several others, the larger number of which died on the voyage to England. It came to my hands about the end of the month of July in perfect health; and when presented to me the only caution given with it was, that I should be careful to provide it with water; and, it was added, that those which had died on the passage had refused it, whilst such as drank freely remained alive. To this observation and recommendation, however, I paid no attention; as a Mr. Jackson, who studied the habits of this creature in its native country, in his *Account of the Empire of Morocco*, had asserted that the chameleon was not accustomed to drink.

The example which thus came into my possession measured ten inches in length, of which the tail was four inches and a half. The head compressed, jaws of equal length, furnished with slight cartilaginous teeth. From above the upper jaw commenced on each side a ridge, which passing

backward formed an elevated crest of a triangular shape, the posterior edges of which passed down, one on each side, to the hindmost angles of the jaw. The eye large, projecting, conical, covered with the common skin; the pupil deeply seated in a hole scarcely larger than would be made with a pin. It is black and lively, and encircled with a gold coloured iris that is not wider than a thread. The projecting eyeball is capable of very extensive movement, and the movements of each eye are independent of its opposite; so that they are rarely seen directed to one object, except when this creature is intent on seizing its prey. The body is usually much compressed, but on the inhalation of air it becomes greatly distended; and it may be readily supposed that the difference in its appearance from this cause was what led to the opinion that air formed the material portion of its diet. The back is ridged, and, on account of the tubercles on it, slightly serrated; the belly also has an obscure ridge. Above the hind legs the body is slender; the tail flattened at its origin, round and tapering through its posterior half; the legs long, those behind longest and with a very extensive motion at their articulation with the body: the claws sharp, five on each leg, and united in sets; that is, on the anterior legs two of the toes are joined together on the outward side and three inward; on the hind legs three are joined together on the outward side and two inward. The body is covered with slight papillous elevations.

This creature moves slowly and with much apparent deliberation, especially when on the ground; but its favourite place of resort is a bush or branched stick, along which it proceeds with great care, never losing its grasp with one hand —as its singularly formed feet may well be termed—until it has secured a firm holdfast with the others; and the tail at the same time is employed in keeping itself safe by twisting round the branch on which it is to advance. This last named expedient is especially needed, in order to keep the body erect when on a slender twig; since for this purpose the feet alone appear to be of comparatively small service.

The colour of the chameleon is subject to continual change; but if a creature that rarely retains the same hue for ten minutes together can be said to possess one which may be termed its own, it is dusky brown, or almost black, nearly approaching to the darkness of soot. This it is which it assumes when it compresses its sides, and places its body with the plane of its surface to be exposed to the direct beams of the sun, so as to receive the full benefit of its rays: of which, as we shall have further to remark, the light is of more importance to its health and comfort than the heat. And when thus enjoying itself even the mouth is extended to receive the influence, although

at other times it is kept closely shut. It was noticed also that as a dingy black was the common colour when enjoying itself in the usual habit of basking in the sun, a light, or whitish yellow prevails when it is asleep; during which time it never changes its position.

Desirous of obtaining a knowledge of the temperature of its body, at nine o'clock of the evening of the 18th of August, when a thermometer in the room stood at 64°, this instrument was moved carefully to the side of the chameleon, when the colour changed from yellow to greenish, and then to deeper green, followed by purple spots, and it expanded itself by inhaling air, an action which sometimes is accompanied with a rushing or hissing sound, the lungs appearing to occupy the lower portion of the belly. While the thermometer lay in contact with its side, in a few minutes it rose to 68°; and a few hours afterwards, when the animal was still asleep and distended with air, with the colour a light yellowish green, and the thermometer in the room stood at 63°, on its being applied to the side it again rose to 68°. At this time, although the touch of the thermometer did not cause it to awake, two rows of purple spots made their appearance on the former ground; and it was observed that whenever two rows of spots were produced they were large, and in one situation and direction.

On another evening, at eleven o'clock, when the thermometer stood at 62°, and the chameleon was asleep, with the colour light yellow, although the touch of the instrument did not cause it to awake, yet the colour changed to darker, and it became covered with numerous purple lines; and then, in a few minutes the colour was dark green with obscure purple spots. But both sides do not always adopt the same colours; for while basking in the sun with the side towards the light a very dark brown, the shaded side was lighter, with green tints and two large rows of purple spots, and yet sometimes spots in the same order are altogether white. When asleep at night the colour was light yellow, with two rows of white spots, on holding a lighted candle at only a sufficient distance to communicate warmth, the side thus acted on became of a uniform brown, while the other side continued of the former light yellow. Afterwards, while still asleep, and the colour was yellow with two rows of white spots, when a candle was held within the distance of three inches, the side exposed to the candle became brown with a row of deeper brown spots, and the other side continued with the unchanged light yellow and white spots; the change when it took place not requiring more than a minute, and within a minute afterwards, on removing the candle both sides were of a greenish yellow with

two rows of large purple spots. When the stick on which it rested was touched gently, without waking it, it became instantly covered all over with minute brown spots. On another occasion, when the colour was altogether yellow, a book was held so as to cast a shade on the anterior part of the body, while a candle was held within four inches of the hindmost portion; and then presently the illuminated part changed to a light brown, while the shaded portion remained as before; and when the screen was removed the exact limit of the shade was visible. When again the colour was yellow with two rows of white spots, in breathing on it so gently that nothing beyond the warmth of the breath could have been perceived, it immediately became covered with minute brown spots on both its sides; and at all times it was discerned by examination with a lens, that the colours existed entirely in the very small tubercles with which the body was covered, and not in the skin which lay between them.

I had hitherto paid no attention to the question whether it was necessary to its health that it should be supplied with drink; but it was not long before an opportunity was afforded for removing all doubt on that subject. Whilst the chameleon was near me at a window, basking in the sun, I was engaged in drawing the figure of a fish; and in order to preserve it alive, it had been wrapped up in sea-weed that was charged with salt water. Having removed the weed, some fresh water was poured on the fish, on perceiving which the chameleon immediately left its station at the distance of about a foot, and hastened with unusual speed to the place; where it scrambled into the vessel, and began to lap the water by repeatedly placing its tongue in contact with the fish, in which action the fleshy portion of its tongue being thrust a little beyond the lips, and then lifting its head, it swallowed the water in repeated efforts. When the fish was removed to different parts of the vessel, the chameleon followed it, without being alarmed, as it usually was, at my meddling with it. In order to ascertain whether it was the salt that might be still on the fish which attracted its attention, I sprinkled a portion of the fish with salt; but when it touched this part with its tongue, it turned away to where the water was fresh; but having lapped it for a moment it returned and applied its tongue to a portion of the fish which I had newly turned up; and it was from this manner of proceeding that I concluded its habits to be to quench its thirst by taking moisture from some fixed surface rather than by drinking from a pool or floating liquid. At this time the quantity of water swallowed appeared to be equal to a tablespoonful, and when satisfied its sides had become very much distended. From the 23rd of August this

chameleon did not again drink until the 12th of September; and I afterwards observed that it required water once in about a fortnight. As the opinion that the chameleon does not drink was thus proved an error, so it seemed equally clear that the popular opinion of its assuming the colour of any substance on which it rests is equally so. It has passed over and rested on carpets variegated with different colours—a large green cloth, a large growing myrtle, with other coloured substances, without my being able to discern that there was ever any connection between the colour of its surface and that of the material on which it rested. On one occasion, indeed, there appeared something like this; for when it had made its escape to the outside of the window, it became so much like the stones on which it rested—black and white—as to escape observation for a considerable time; but it has been known to assume precisely the same appearance under other circumstances, and when surrounded with substances very different in colour. It was not kept in greater restraint than was afforded by a large room; but after continuing for several hours on a green or scarlet cloth, or on green vegetables, it was not seen to assume these colours; nor, indeed, was it ever seen to assume the colour of scarlet.

It was only after it had been a fortnight in my possession, that I had an opportunity of seeing it take a fly; but after this it not only took all that came in its way, but would seize them as fast as children would bring them; and it even became so familiar with the act as to take them repeatedly from the hand. It was thus easy to measure the distance to which it was able to dart its tongue in seizing its prey, which was found to be six inches—or rather more than the length of its body; but the more usual distance was about three inches, and it was very rarely seen to miss the mark. In approaching a fly, the motion at first was slow and cautious, and within a favourable distance the mouth opened and the tongue protruded slowly to the extent of about an inch, beyond which it darted swiftly, although not as has been represented, for it has been described as more sudden and swift than human sight could follow it. The extremity of the tongue is usually flat and pointed; but when darted forward to its prey, the end is formed into the shape of a (large) pea, the middle being the most projecting part. To this the fly adheres by means of the tenacious mucus with which it is covered, and it is instantly conveyed into the mouth. But it is necessary to the success of this operation that the fly should be on some fixed substance, and almost, if not entirely, at rest; for if otherwise the chameleon will not attempt to take it, and repeatedly it has been observed to protrude a portion of the tongue,

and then withdraw it as the fly has been in motion, until at last it has either secured the prey, or given up the attempt.

About the middle of September, when the weather had become moist, and the thermometer had ceased to stand at 60° at noon, its activity was greatly lessened, scarcely moving when awake, and sleeping the greater part of the day; but the appearance of sunshine restored some degree of activity. It was noticed also that when asleep at night, with the thermometer below 56°, the colour had ceased to be yellow or whitish, as was formerly the case under these circumstances of rest, but pea green. But the greatest changes were in the first week of December, when, with the thermometer at about 50°, it ceased to take the flies presented to it; and when the thermometer was at 46° it had become so torpid as, although taken in the hands, it seemed unable to move or open its eyes. As the coldness of the air appeared to be the cause of this insensibility to impressions which at one time effected visible alterations in its actions, as well as in its changes of colour, it was often brought within the influence of artificial heat; but this appeared to produce little effect, and it never spontaneously sought the aid of the fire; whereas the faintest sunbeam was a source of enjoyment, in which it would bask, and for the sake of which it would change its position as the gleam moved in the room. Its breathing at this time appeared distinctly to be counted; the portion of its body presented to the sunbeams was darker than the rest, and when, on the 5th of December, it was found dead, the general colour of the surface was dark.

From later and extensive observation of the change of colour found in fishes, it seems certain that there is no physiological analogy between what occurs in them and in the chameleon, but that the circumstances, as well as the causes, are altogether different.

ON THE VARIATIONS OF CERTAIN CRUSTACEA, IN RELATION TO THE THEORY OF THE ORIGIN OF SPECIES BY NATURAL MODIFICATION.

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DARWIN'S theory of the origin of species has outlived the virulent abuse of an extreme school of scientific, or one might more correctly say, of unscientific opinion, and has entered upon a second phase of existence. It has now to undergo the ordeal of a searching comparison with the phenomena of nature; with phenomena not only old and familiar, but with many others which have been brought to light since the publication of Mr. Darwin's treatise, and with a still greater multitude which must before long reward the efforts of such laborious students as are now engaged in the pursuit of natural history. The time must come, though we do not yet see it, in which educated men will be willing to receive new truths of biological science, however much these may conflict with preconceived ideas, in a temper as calm as that with which they now contemplate those revelations of geology and astronomy which a past generation counted no better than damnable heresies.

It is obvious that the lower orders of animals present a field on which the many details of descent and variation can be examined with much greater facility than amongst more highly-organized beings. The great numbers in which members of many of the lower groups may be obtained, both in a recent and fossil state, their excessive fecundity, their curious metamorphoses, and other circumstances, render it highly probable that amongst them we shall look with the greatest chance of success for information regarding the true relationships of species, and the modes in which they have originated.

There is, doubtless, at the outset, a considerable difficulty in accurately defining what we mean by a *species*. This must, in the long run, be left to the discretion of each observer in the department which he specially cultivates. We can lay down no recognized rule by which one nearly allied species may be absolutely, and without fear of contradiction, separated from another, and the practice of different naturalists varies in this respect very widely. Thus while "M. Grenier enumerates only twenty-three roses for the whole of France, M. Dèsèglise describes or mentions one hundred and seven in his elaborate monograph of the French Roses; and M. Boreau, in the last edition of his Flora, gives seventy-four for the

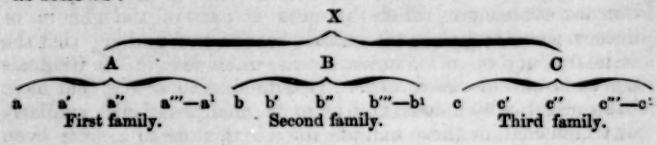
Central Departments only."* Our common bramble, *Rubus fruticosus*, is a parallel example. By some botanists it may still be, as it used to be, considered as one very variable species; by others it is divided into a multitude of distinct species: that these are "good" species, according to any possible morphological or physiological test, I cannot believe, though their distinction by specific names may be very convenient to the botanist. But suppose a few links in different parts of this chain to be lost, then there would be no question as to the "goodness" of the several species. And this continuity is equally apparent in the animal kingdom. Dr. Carpenter's conclusions with respect to the *Foraminifera* are that their range of variation is so great as to include, not merely the differential characters which have been accounted specific, but also those upon which the greater part of the genera, or even in some instances the orders, have been founded; that the ordinary notion of species as assemblages of individuals marked out from each other by definite characters that have been genetically transmitted from original prototypes similarly distinguished, is quite inapplicable to this group; since even if the limits of such assemblages were extended so as to include what elsewhere would be accounted genera, they would still be found so closely connected by gradational links, that definite lines could not be drawn between them; that any arrangement of genera and species which may for convenience be adopted, must be regarded merely as assemblages of forms characterized by the nature and degree of modification of the original type, which they may have respectively acquired in the course of genetic descent from a common ancestry; that even as to the family types it may fairly be questioned whether analogical evidence does not rather favour the idea of their derivation from a common original than that of their primitive distinctness.†

My object, however, in the present paper, is to give a brief account of some recent researches of two German naturalists, Dr. Müller, and more particularly Dr. Claus, the Professor of Natural History at Marburg. The work of Dr. Fritz Müller, *Für Darwin*, I know only by some extracts given about a year ago in the *Annals and Magazine of Natural History*. These are especially interesting, inasmuch as the author conducted his investigations on a deductive, instead of on the usual inductive plan; that is to say, instead of in the first instance ascertaining a number of facts, and then looking for some general explanation of them, he, to begin with, set before himself Darwin's theory of descent, and said, "If this theory be

* J. G. Baker, *Review of the British Roses*.
† Dr. Carpenter, quoted by Mr. Grove, Address to British Association.

true, we ought in such and such a case to find such and such peculiarities." He then set to work to investigate on this basis, and the following is a very striking example of his results.

Crabs are divided into several natural families, so grouped because all the species of each family possess certain characters in common which distinguish them from those of neighbouring families. This, according to Darwin's hypothesis, is the natural result of their descent from one common ancestor. Then the species of all these families, which we may call A, B, and C, present certain ordinal characters common to all, and due to the fact that the families A, B, and C, descended from a more remote type X. This may be more plainly shown as follows :—



Now it is remarkable that in each of these families we find, as exceptions to the normal mode of life of the crabs, certain terrestrial species. It is permissible to suppose, *à priori*, that these must present certain modifications of the respiratory apparatus, enabling them to breathe air, and if each terrestrial species has gradually renounced, for itself, the aquatic mode of life, there is every probability that each would present a modification, *sui generis*, very different from those presented by others. If, on the contrary, observation proved that all these terrestrial species present the same modification of the respiratory apparatus, the Darwinian theory could only account for them by assuming that these terrestrial species belonging to various families, which we may distinguish as a^1, b^1, c^1, descended from a common type, O, which had already acquired the organic conditions of aërial respiration. But then the theory would contradict itself; for while the study of the respiratory organs would compel us to make a^1, b^1, c^1, descend from O, the distinctive characters of the families to which they belong lead us to assign to them a different origin, namely, from X through A, B, and C.

The details of the organization of the respiratory apparatus in the land crabs have hitherto been unknown; and thus a fine field of investigation was open to Dr. Müller. If he found in the terrestrial species of different families the same arrangement for effecting aërial respiration, the Darwinian theory would be irrevocably condemned, but if he should discover differences so complete as not to be reducible to the same type,

this would certainly furnish a strong argument in favour of the theory, and the latter alternative has proved to be the true one.

In an *Aratus* which climbs upon the branches of the mangroves, and in a *Grapsus* which runs about the rocks of Santa Catharina, the air finds entrance to the branchial cavity by a fissure situated above the last pair of feet. These crabs open the respiratory fissure by elevating the posterior extremity of the carapace. This aperture is consequently at the extremity of the branchial cavity opposite to that by which water enters and issues; for the apertures for the ingestion and egestion of *water* are in the same position in all crabs.

The genera *Sesarma* and *Cyclograpsus*, belonging, like the preceding, to the family *Grapsidæ*, contain species living in holes on the shore. These possess the same posterior respiratory fissure: but it is difficult to see the gaping, as the animals rarely open it, indeed only when they have been a long time out of the water. This is due to a very curious arrangement, which does not exist in the preceding species, and which enables these animals for a long time to respire the air dissolved in the water that bathes the branchiæ. The region which separates the aperture for the reception and emission of water is, as it were, reticulated, and bristles with small recurved hairs. The water issuing from the egestive orifice spreads in an instant over this network of hairs, and becomes saturated with air, after which it is conducted by a special arrangement into the ingestive aperture. The same portion of water may thus pass through the branchial chamber a great many times, carrying always a fresh supply of oxygen with it. In moist air this circulation of water may be maintained for a very long time, but when the provision of water is evaporated, the crab has recourse to the posterior aperture for aërial respiration.

The arenicolous *Ocypodæ* have been so completely estranged from an aquatic mode of life that a stay of one day in sea-water is sufficient to kill them. It has long been observed that in these animals the third and fourth pairs of feet are exceedingly close together. Their contiguous surfaces are clothed at the margins with a dense coat of hairs. It has been supposed that these hairs were intended to diminish the friction of the surfaces, but this is evidently a mistake. Dr. Müller has discovered between the bases of these approximated legs an aperture leading into the respiratory cavity. This arrangement exists in several species of the family, particularly in certain *Gelasimi*, some of which inhabit the mangrove swamps, whilst others run about upon the sand in open day. It might, perhaps, be said that this arrangement was necessary

to protect the respiratory cavity from the entrance of the sand in which the creatures live, but a species of *Gelasimus*, which lives far from the sands, in the mangrove forests, in company with several *Grapsidæ*, nevertheless has the respiratory orifice concealed between the third and fourth pairs of feet.*

The limits of this paper do not permit me to follow Dr. Müller in his investigations into the development of various crustacea. The metamorphoses which these animals undergo are amongst the most wonderful in the whole range of natural history, fully equalling, and perhaps, from their significance even exceeding in interest, the more generally known changes of the *Lepidoptera*. The phenomena of embryonic development in all kingdoms of nature lend very strong support to Darwin's theory, and are indeed perfectly inexplicable without recourse to some such hypothesis, and Dr. Müller has, by his recent investigations, added considerably to our knowledge of these amongst the crustacea, and given additional reasons for belief in the theory of transmutation. For the details of his researches I must refer the reader to the translation from which I have already quoted largely.

The *Ostracoda* belonging to the families *Cyprinæ* and *Cytherinæ* have been hitherto divided into genera and subgenera on the strength of characters taken in great measure from the carapace, or outer shell of the animal, and more particularly from those of the hinge-joint. This mode of classification must in time give place to one founded on the structure of the animals themselves; but these are often so difficult to obtain in a living or unmutilated state, and are withal so difficult to examine thoroughly and minutely without the aid of a large supply of specimens, that a thorough knowledge of their organization must involve the labour of a lengthened period. Meantime, a good beginning of the work has been made by Dr. Zenker, Professor Lilljeborg, G. O. Sars, and other naturalists. But by far the greater number of *Ostracoda* hitherto described are fossil species, which can be known only by their shells; or recent species, which have as yet only been examined in a dry state. In these cases the characters of the hinge-joint are very valuable, exhibiting peculiarities which seem to coincide pretty definitely, so far as we at present know, with certain differences of the animal organization.

When I began the study of the *Ostracoda*, I supposed that every species (I refer now to those of the families *Cytherinæ* and *Cyprinæ*, which comprise a vast majority of the British species) might unhesitatingly be placed, by virtue of the peculiarities of the hinge and external shell-surface, in one or other of the established genera. What I wish now to show, is that

* *Annals and Magazine of Natural History*. Third Series; vol. xv.

no such arrangement is possible without leaving numerous intermediate forms—evidently, as it appears to me, links in a chain of descent—which cannot be referred with certainty to any genus. Up to a very recent period, the recognized genera of these two families, founded upon characters of hingement, were as follows:—(1) *Jonesia**, the hinge of which is perfectly simple, the edge of the valves being quite straight, and held in opposition by ligamentous tissue; (2) *Cytherideis*, in which the edge of one valve projects sharply at each extremity, and articulates with corresponding excavations or notches of the opposite valve; (3) *Cytheridea*, bearing on the right valve two knurled or crenulated elevations, which are received into shallow fossæ of the opposite valve; (4) *Cythere*, which, instead of knurled elevations, bears two strong projecting teeth, articulating with corresponding fossæ of the left valve, and between the two teeth a bar which is received into a furrow of the opposed valve; (5) *Cythereis*, similar to the foregoing, except that the bar and furrow are obsolete; (6) *Bairdia*,† in which the left valve is much the larger, overlapping considerably the edge of the right valve, which is received within it.

But between the typical forms of *Jonesia* and *Cytherideis* there are many gradations of hinge character, no two species being exactly alike in this respect. Many species, instead of having margins either absolutely straight or angularly notched, have more or less pronounced curvatures. In this category may be placed *Cythere variabilis*, Baird, *C. contorta*, Norman, and other species. The genera *Cythere* and *Cytheridea* are not, so far as we at present know, so closely interwoven; still there are several species which are intermediate in character. One of the commoner littoral species, *Cythere lutea*, Müller (*C. reniformis*, Baird), has hinge-processes which are distinctly crenulated, and many species possess a crenulated bar between the two terminal teeth. *Cythere* and *Cythereis* are so inextricably united that it is impossible to draw any line of separation which at all takes into account the character of the hinge, and even if we look to more general peculiarities, the task of discrimination is scarcely more practicable. The genus *Bairdia* is very distinct indeed in its most strongly marked forms, the great inequality in the size of the two valves, and the peculiar overlapping of the left hinge-margin being unmistakeable characters. But besides that the tendency to a

* The genus *Jonesia* was proposed by myself (*Trans. Zool. Soc.*, vol. v.), but appears to be equivalent to *Bythocythere*, G. O. Sars, a genus founded on exclusively *animal* characters. When my paper was written, I was not acquainted with the valuable memoir of M. Sars, which indeed was probably not printed at the time.

† The genus *Bairdia* is related to *Cypris*, belonging to the family *Cyprinæ*, and not *Cytherinæ*, with which it has been hitherto classed.

slight inequality of the valves is very general amongst the *Ostracoda*, there are some species which possess this character strongly developed, and are at the same time not at all referable to the genus *Bairdia*. *Cythere convexa*, Baird, is a well-marked example, the carapace having the general form of *Bairdia*, and also the unequal and overlapping valves, but exhibiting at the same time the strongly-developed hinge-processes of *Cythere*.

It may also be noted as a most interesting fact that there exist several genera of marine *Ostracoda*—not hitherto described as British*—which are distinctly intermediate, in the character of the contained animals, between the (chiefly) marine ambulatory genus *Cythere*, and the purely fresh water, natatory genus *Cypris*. These intermediate genera are—*Bairdia*, *Pontocypris*, *Paracypris*, and *Argilloecia*. The first-named group is represented in the British seas by several species, *B. inflata*, Norman; *B. acanthigera*, Brady; *B. intermedia*, Brady; *B. obtusata*, G. O. Sars; *B. minna*, Baird. Of *Paracypris*, we have one British species, *P. polita*, G. O. Sars; of *Pontocypris* two species, *P. semilata*, G. O. Sars; and *P. trigonella*, G. O. Sars, while the genus *Argilloecia* seems to be unrepresented on our shores.

The object which I have now more especially in view is to give a brief abstract of a memoir recently published by Dr. Claus‡ on the *Copepoda* of Nice. This paper has not, so far as I know, been yet translated, or even noticed, in England. The object of the author, besides the description of new species, was to give an account of some remarkable variations which have come under his notice during a long study of this tribe of animals, and I propose now to notice, very briefly, some of the facts which he describes.

The *Copepoda* of Nice, are, as might be expected from geographical considerations, much more nearly related to those of Messina than to those of the North Sea, but the following particularly northern forms are found likewise at Nice:—*Anomalocera Patersonii*, an Atlantic *Pontella*, *Cetochilus septentrionalis*, which forms the chief food of the Arctic whales, but attains in that northern region to a much greater size; also *Tisbe furcata* and *Euterpe gracilis*. Other species occur less commonly, such as *Ichthyophorba denticornis*, of which the Nice variety is of strikingly slender form, and has, in the male, remarkably small clasping feet. The variations noticed in *Dias longiremis* are also remarkable.

* Some of these species have been described from the external shell characters by British authors, but of the animals themselves nothing has been published in this country.

‡ "Die Copepoden-Fauna von Nizza: ein Beitrag zur charakteristik der formen und deren Abänderungen im sinne Darwin's." Marburg und Leipzig, 1866.

Some northern species are, at Nice, represented by very nearly related forms. Thus the northern *Dactylopus Stromii*, gives place to *D. similis*; the northern *Harpaticus chelifer* to *H. nicœensis*. Similar differences may be noted between the *Copepoda* of Nice and Messina, the species and genera of which places are for the most part the same, and, in many cases, of invariable form, *e.g.*, *Euchœta Prestandreœ*, and *Candace melanops*. But there is a constant deviation observed in *Calanus mastigophorus*.

The most important distinctive characters met with amongst the *Copepoda* are in the size and colour of the body, the form and length of the tail, the form and number of joints of the upper antennæ, the character of their appendages, the character of the eyes, etc. The colour of a species may, however, be due to the distribution of pigment in various form through the external tissues of the body, or it may result merely from masses of food lodged in the alimentary canal, or from the natural colour of organs such as the ovaries. Indeed, it is often very difficult to decide how far in particular cases variations of colour may depend upon outward conditions, such as those of food and temperature.

It is worthy of remark that some very common species have a large and a small variety, and that we do not find intermediate sizes. These may, perhaps, exist, but they are seldom seen. Thus a large form of *Dactylopus similis* is 1·2 mm. in length, the small variety only 0·7 mm. *Tisbe furcata* also varies at Nice from 1·4 mm. to 2·3 mm., and there is a form of *Antaria mediterranea*, in which some of the middle segments are wholly, or in part, wanting. As connected with this part of the subject, I may note that I find a variety of *Dias longiremis* in brackish water at Burgh Marsh, Cumberland, also in similar situations at Hartlepool and Alnmouth, the length of which is only one-thirty-fifth of an inch, that of the normal form being one-twentieth of an inch.

The characters of the tail setæ, and the joints of the antennæ are of great specific importance amongst the *Copepoda*, and there are many striking variations in these respects, as, for instance, in *Cyclops serrulatus*, *Antaria mediterranea*, and various *Corycei*. Differences in the size of the various joints of the antennæ are very common. In *Harpacticus nicœensis* the third and fourth joints are often much elongated; in a large variety of *Tisbe furcata*, the size of each joint is subject to much variation; and there is also a variety of this species which bears a very large secondary branch on the lower antenna; the terminal joint being excessively elongated. In *Dactylopus similis* the fifth and sixth joints are very variable,

and the nearly related *D. Stromii*, of Heligoland, likewise shows a similar tendency to variation. Circumstances of this kind prove that closely-allied species are subject to changes of a similar nature. *Dactylopus Stromii* seems especially liable to great divergence. The seventh antennal joint is of very uncertain length, and is even sometimes divided into two joints. This Dr. Claus has observed only in one instance, the antennæ having nine, instead of eight joints, and in their relative size simulating those of the allied genus *Thalestris*. Of thirteen known species of *Dactylopus*, far the most have eight-jointed antennæ, two species have ten joints, one has seven and one five. *Nine*-jointed antennæ are not met with normally in any species of *Dactylopus*. Thus it appears that through individual alteration characters may be acquired which one is accustomed to regard as being even of generic importance. In the same way, the Mediterranean species of *Harpacticus* have *nine*-jointed antennæ, the northern species being eight-jointed. Greater and smaller individual differences may occur in all parts of the body, and these often occur in such wise that though there may be no intermediate forms, it is quite impossible to regard the animals as belonging to distinct species. We must in such cases allow the influence of "time's effacing fingers." Highly interesting and important in this view are the variations in the length of the third and fourth antennal joints of *Harpacticus nicæensis*. The stronger, and, on the average, the larger form, has a heavy, strong body, ill-bred apparently, inactive and wanting in mobility, the antennæ clumsy, with their third and fourth joints short and thick, the second joint very long; the second foot-jaw ends in a strong, massive, clasping hand; the first pair of feet are armed with doubly-curved claws; the feet, especially the last pair, are strong and clumsy, all the setæ showing a tendency to become plumose. The smaller and slenderer breed has longer antennæ, the third and fourth joints of which are much elongated; the prehensile apparatus of the foot-jaws and first pair of feet more slender, and there is also a much slimmer, slenderer form of the limbs. In general structure and conformation of body, in the peculiar arrangement of setæ, the serration of the abdominal segments, in short, in those points where distinct species mostly diverge, there is here a striking agreement. "After diligent inquiry," says Dr. Claus, "these differences remained unexplained, and I was inclined to consider them as mere individual variations. But further investigation of all portions of the body convinced me that two distinct forms, with qualities diversely useful, had originated two separate races, one slender, swift, and agile; the other, clumsy in figure, but robust and powerfully armed. The two

races are so far separate, that intermediate individuals, partaking of the characters of both, are not met with. The upper antennæ, however, in each case, show a tendency to similar variations. At the same time, these variations are not so profound that they might not have been acquired singly or in combination. The differences in the relative size of the claws and prehensile organs may be traced back to the youngest stages of growth. . . . Many species may, no doubt, have been founded on characters no more distinct than these, and on mere deviation of character in the joints, which a critical investigation would prove to be worthless."

When the advocate of immutability urges the absence of forms intermediate between distinct species, he forgets that between acknowledged *varieties* it is mostly impossible to obtain connecting links.

Besides forms, varieties, and nearly allied species observed in places near to each other, Dr. Claus notes examples of variation depending on influences of climate and other external conditions. He lays little stress on varieties of colouring, but much upon difference of size, instancing the *Cetochilus septentrionalis* as found at Nice, which is only one-third of the normal size of the species. The little *Calanus mastigophorus* which he distinguished at Messina by the long, whip-shaped, antennal setæ, occurred also at Nice, but without these setæ. Very remarkable also are the differences of form in the male prehensile foot of *Dias longiremis*. While the fifth feet of the females of Nice and Heligoland are in all essential respects the same, that of the Nicæan male has a stronger claw and appendage, to allow, as it seems, of a stronger grasp. We have here, as in the case of *Orchestia Darwinii*, two different males in the same species, and can only explain the deviation as the result of natural causes connected with different localities. The difference of the feet is indeed so striking as to have led to the supposition of the two forms being distinct species. An instance of concurrent variation of different parts of the body occurs in the *Ichthyophorba denticornis* of Nice and Heligoland. The former is not only smaller than the northern species, but has proportionally far more slender armatures of the antennæ, and a much less marked angular projection of the last segment of the body, and in the males much weaker prehensile apparatus of the fifth foot. It thus stands, in size and conformation, between the northern *I. angustata* and *denticornis*, the distinctions, indeed, are here so sharply defined that according to some schools of naturalists they might properly constitute species rather than varieties. "The opponent of the origin of species by descent," continues Dr. Claus, "asks to see forms of an intermediate character. When we succeed in showing

these, which, from the requirements of natural selection, must be but seldom, he immediately answers that the two extreme forms are not good species, but only varieties. This is a vicious style of argument. Darwin rightly says that facts seems to prove the fruitfulness or sterility of animals *inter se*, to be a criterion of no value whatever, but his opponents maintain that the descendants of varieties are fruitful, and of species sterile, *inter se*. So when Rouy in Angoulême obtained many successive generations of a breed between the hare and the rabbit, they directly affirm that these animals had been hitherto misunderstood, and that they are evidently only varieties of the same species. In the same way, however, as we discriminate species by characters occurring either singly or in combination, we are entitled to believe in the general unfruitfulness together of animals belonging to those forms which we designate by the name of species—a peculiarity imparted to them along with many other characters, and having in itself nothing requiring separate explanation."

A great many people fear to believe in the derivative origin of species, because they vaguely fancy that the doctrine leads to materialism, and even worse phases of belief or unbelief. They charge its advocates with inability to appreciate whatever cannot be weighed and handled, with a want of reverence for the spiritual and unseen. And, indeed, it is obvious that material organisms must be subject to the laws which regulate *matter*, just as much as spiritual entities must obey the laws of spirit. But though we believe that the phenomena of origin and creation are the result of the operations of immutable law, no less as regards species and races than as regards the individual; we believe likewise that these laws are at once an expression of the will, and a revelation of the wisdom of the Eternal, and that through them "the whole round earth is every way bound by gold chains about the feet of God."

A NEW CHARR* FROM BRITISH COLUMBIA.

BY JOHN KEAST LORD, F.Z.S.,

Naturalist to the North American Boundary Commission; Author of "The Naturalist in Vancouver's Island and British Columbia."

Sp. Ch.— Scales minute. Head and body rather compressed; the height of the head equals the length of the head, and is two-ninths of the total (without caudal); the length of the head is one-half the distance between the snout and the vertical from the origin of the dorsal fin. Snout very obtuse, scarcely longer than the diameter of the eye, which is three-fourths of the width of the interorbital space. The lower jaw is a little shorter than the upper; maxillary of moderate length, scarcely reaching to the vertical from the margin of the orbit. Teeth of moderate strength; those along the medium line of the hyoid are very small. Præoperculum with a very distinct lower limb. Fins rather small; the length of the pectoral is less than that of the head (without snout), or one-half of the distance of its root from the ventrals; caudal fin slightly emarginate. Back and sides reddish olive; sides with numerous round light-coloured spots. Belly whitish powdered with reddish olive; paired fins and anal colourless; caudal immaculate. Pyloric appendages very long and wide.

"This is one of the smallest species of charr, both our specimens having the abdomen filled with mature ova."

It would be of no practical use to give a lengthy description of the specific differences which separates the charr from the rest of the *Salmonidæ*. The charr we are familiar with, as tenanting British waters, are as a rule resident in deep lakes. Yarrell, in his *History of British Fishes*, vol. ii., p. 125, tells us "The charr generally inhabit the deepest parts of those lakes, in which they are found, and afford but little amusement to the angler." The charr are very seldom known to wander into any of the streams, by which these lakes are either supplied or drained, except at the season of spawning, and their decided partiality for clear water and a hard bottom is then very conspicuous. The spawning season is in November and December.

I must ask my readers to forget for a short time the beautiful lake scenery we are all so justly proud of, to leave the haunts of the British charr (with which, if the reader is a disciple of the "gentle art," he is pretty sure to be familiar), and to visit with me, in imagination, its near relative, a dweller in the

* *Fario Lordii*, Nov. Sp., Gunther, Brit. Mus. Catalogue of Fishes, vol. vi., p. 148.

wild regions of North-western America. Let us suppose ourselves to be entering the Fraser River, which, I need hardly say, is the principal navigable stream flowing through British Columbia; it heads from the Rocky Mountains, drains a large extent of country west of the Cascade Mountains, and empties into the Gulf of Georgia, about six miles north of the British and American boundary line, the 49th parallel of N. lat.; the entire length of the river may be roughly set down as 1000 miles.

A small steamer conveys us so far as New Westminster (which is the capital town of British Columbia), a small straggling place built on a steep wooded slope, about fifteen miles from the mouth of the Fraser River. Here we charter a canoe, and provide a stout crew of Indians, and if we start early, we may manage to reach Fort Langley by sundown. This so-called fort is a trading station belonging to the Hudson's Bay Company, whereat in salmon-time immense numbers of these lordly fish are salted and barrelled, to be eventually disposed of at the Sandwich Islands and San Francisco. Putting up cranberries also, at one time, formed a large item of the trade done at this station. The berries were bartered from the Indians, then headed into casks made at the fort, these casks were lastly filled with water, through a hole in the head bored for the purpose, and then plugged up. We sleep at Fort Langley, and paddle away again early in the morning. On either side of the stream (which in this, the month of August, is swift and turbulent), rise steep sharp-pointed hills, deeply cleft into ravines, and densely clothed with massive pine-trees, from the water's edge to the very topmost pinnacles of their craggy rocks. Here and there some tributary stream makes its way from amidst the trees, and, as we pass, little clusters of Indian lodges are revealed, resembling hillocks, but from which many columns of white smoke are stealing up through the trees, and but for such tell-tales we might have gone by the village fifty times, and have been none the wiser. Suddenly, as we round a sharp bend in the river, we come into a wide expanse of water, tranquil as a lake (these lake-like stretches of water are peculiarly characteristic of the scenery on the Lower Fraser) green grassy banks like verdant meadows extend for some distance from the water's edge to meet the bases of the hills, to be at last absorbed amidst their timbered slopes. These banks are favourite camping-grounds for the fishing Indians, and we can make out, as we paddle slowly past, little fleets of canoes, laying bottom uppermost on the grass, whilst behind them are lodges of all sizes: many camp-fires are burning brightly, and round about them groups of dingy savages loll lazily or squat on their heels. A-head of us are four canoes, each of

them manned by two nearly nude savages, the one paddling is seated in the stern, the other, standing in the bow, is armed with a spear seventy feet in length. These Indians are sturgeon-spearing—sturgeon five hundred, and sometimes as much as seven hundred weight, are speared and landed with these frail canoes, that the slightest inequality of balance would upset in a moment. We land in the evening on the "Sumass spit," a large sand-bank at the junction of the Sumass and Fraser Rivers. Here we find a regular Indian town, not very large as regards the number of its houses, but each house contains from nine to twelve families. The houses are built like sheds, with cedar planks, a small part of the interior is apportioned to each family, who sit or lie on the bare ground round the fire, every family has its own fire, and the smoke from the whole of them finds its way out as best it can. A stockade about twelve feet high, constructed of small trees and stout poles, encircles the village; this defence is pierced with small apertures, through which arrows or bullets, if need be, can be fired at an enemy. About three miles higher up the river lives another tribe, we shall not see their village, because it is situated inside a small island, and, thus craftily hidden from sight, any one going up or down the river, would not know of its existence. The owners, the Chilukweyuk Indians, are dire enemies of the Sumass tribe, hence the latter, being the weaker, need a stockade to prevent their foes from pouncing upon them unexpectedly. These Indians live in a great measure upon white fish (*Coregonus quadrilateralis*) and salmon, fresh and sun-dried.

We have fifty miles more to accomplish ere we reach Fort Hope, our destination. The river above Sumass gets swifter in its course, rapids are more numerous and difficult to ascend, and what is most astounding, heaps of drift timber, each heap containing many thousands of immense trees, are piled up at nearly every bend, or wherever rocks, a point of land, or a sand-bank, has offered any obstruction to their onward course. These trees are washed down by the floods, which commence in May, and are at their highest during June and July, at which time the sun rapidly melts the snow from off the hills. If one did not previously know that the river rises quite forty feet during the summer freshets, it would be a puzzle to conceive how such gigantic trees could be piled one upon top of another; as the canoe glides along beneath their shadow, it is precisely like looking up at a cliff composed of huge trees. Two living things only are to be seen on this chaos of wood; one of these, the dipper (*Cinctus Americanus*) hunts busily on the submerged stumps for aquatic insects and larvæ, sometimes quite under water, at others only half immersed; whilst the

other, the "store keeper" squirrel (*Tamias quadrivittatus*) scampers along from tree to tree, chattering, whistling, and scolding, as if in angry remonstrance at so impudent an intrusion into its solitudes. It is ticklish work getting up some of the rapids; paddles are of no avail, and the canoe has to be propelled with light poles (poling a canoe up a swift rapid is a feat I have never seen a white man perform with the same skill as an Indian, not even the oldest and most skilful voyageurs belonging to the Hudson's Bay Company are equal to the red-skins; the art of holding the canoe with the pole, and whilst propelling her against the current, preventing its sweeping her round, is an art Indians, and only Indians, know how to manage) the slightest slip and over we go, with the water running like a mill-race, rocks, boulders, and snags everywhere, and eddies, and whirlpools strong enough to suck down a boat; why, a man would not have the slightest chance of saving himself from drowning, even if he could swim like a beaver; but somehow the red-men get us through in safety. Now and then we pass beneath a rocky cliff, the splintery points of which knock the water into spray as it hurries on its way; then coaxing the frothy current into clefts and hollows, whirls it round in countless eddies. Here in these dark retreats salmon love to linger, as they toil on against every obstacle in search of some gravelly stream, wherein to make a nest and bury their eggs; and we may count these noble fish by the thousand, and then fail to arrive at a fair estimate of the numbers which every year ascend the Fraser and its tributaries. Stages suspended by ropes of twisted bark dangle over these gloomy whirlpools, frail are they in construction, being simply light poles tied clumsily together, one shudders even to look at the fearless savages, as kneeling or sitting on their heels they ply a small round net affixed to the end of a long handle, and one by one land goodly salmon on the treacherous platform. It is no easy feat to lift a heavy fish, flapping and struggling in the full vigour of superfluous health, on to a stage swinging in mid-air, or to knock it senseless with a single blow when it is there; and yet these untutored men manage to do it, every day and all day long. To fall from off the stage must be certain death, and yet they are compelled by hard necessity thus to imperil life and limb in order to obtain food, on which to exist during the biting cold of a six months' winter.

We need not linger to describe all our different camping-places, but we will pass them by as offering little worthy of particular notice. Fort Hope, our destination, is visible a-head, perched upon a bluff some height above the river. The scenery is grand and massive beyond description; lofty

mountains, some of them crowned with perpetual snow, completely shut the river in on both sides. A dense impenetrable forest of pine-trees seem to rise from out the water, and in a series of green slopes end only at the sky-line. But this mass of dark green is so broken, divided, and grouped, if I may so express it, by craggy masses of rock, deep ravines, and narrow valleys, through which streams rattle noisily, that all idea of monotony vanishes, and on every side is a magnificent natural picture, wherein are all the elements requisite to make a landscape beautiful, but on such a scale of immensity, that it fairly staggers one to gaze upon it. The river sweeps past Fort Hope with great velocity, then making a sudden bend to the right, is suddenly lost amidst the jutting points of land and the dense foliage of the forest.

Fort Hope is but a small place, consisting of the Hudson's Bay trade post, some scattered log houses, and a kind of street facing the water, made up of stores, groggeries, billiard saloons, and barber's shops. This town, since the period of which I am writing (being the head of steamer navigation) has grown to be a place of some importance, because one of the routes to Cariboo is *viâ* Fort Hope and Lytton. A steamer in old days did occasionally come up to Fort Hope at certain periods of the year, in order to take away the furs collected there during the year, and at the same time to bring goods for barter with Indians, which goods were destined for the supply of the frontier trading posts.

We are now near the home of our new charr, and I shall continue this imaginary journey, because it will the better enable me to describe the character of the river in which the fish lives, and the kind of country through which the stream flows, matters of importance, as showing how the charr of British Columbia differs in habit and habitat from its better known British brethren.

The distance to our fishing-ground is rather too great to walk comfortably, and the hills are steep, so we will mount our mustangs, and ride. Our route is along a flat at first, covered with shingle and large rounded boulders, which were brought here, in all probability, on the shoulders of the ice king, for in no other way could masses of rock, differing entirely from the rocks comprising the encircling mountains have been transported from a distance. Water power could never have rolled them; their weights must be calculated by tons, not pounds. The flat we are traversing was, most likely, the bed of an ancient lake. The best evidence obtainable respecting the age of these vast accumulations of water-worn stones is at best but very imperfect. Whether this huge continent has been depressed in the mass, or whether the

upheaval in the centre has greatly exceeded that along its margins are speculations for geologists to decide.

These terrace formations, as they are styled, must strike the most obtuse traveller as being unlike anything he has seen before in other parts of the world. There is hardly a valley between the Rocky Mountains and the Pacific coast lower than 4000 feet above the sea in which these shingle terraces are not met with. Two miles across the shingle, which is but sparsely covered with timber, brings us to a beautiful stream, the Qua-que-alla, clear as crystal, and cold as ice. It has a swift rocky course, and as we look into the glass-like water, brigades of salmon (*Salmo lycaodon*) are seen toiling on, all with their heads up stream, literally crowding one another against the rocks and banks, the bright scarlet stripe marking the sides of every fish; the worn noses and large ulcerous wounds that have eaten holes into the living fish, tell their own tales of hardships, difficulties, and privations, endured in obeying an instinct ever prompting them to deposit their eggs as high up in the mountain streams as they can get. Neither can we be blind to the fact that another purpose is fulfilled by the bountiful hand of God, thus directing myriads of fish to quit the sea, and enter rivers intersecting the interior of a continent or an island. This obedience to an unalterable law is a simple means by which heat-yielding materials, and meat requiring sunshine only to cure it (salmon sun-dried will keep sound for years), are floated, free of all freight, to the dwellings of the aborigines who live far inland, and have to endure a rigorous winter and six months snow.

It is not at all overstating the fact to say, that four out of every six of these salmon we are watching, will die as they struggle onwards, and drift back again in rotting masses, towards the ocean from whence they came.

We only follow this stream for a short distance to reach its junction with a second stream, up the course of which we ride by following a narrow trail. Where the forest is a little open we can look upwards through the trees and discern the water-shed of the Cascade Mountains. The waters of the eastern side find their way into the Columbia, whilst these on the west flow into the Fraser. The hill we are ascending is steep, and the river tumbles from rock to rock with tremendous force; a louder roar than we have been listening to, directs us to a waterfall, where the river plunges over a vertical wall of rock, and puts an effectual stop to the salmon's further ascent (bear this fact in mind).

We by-and-by reach a kind of plateau, where the water has a slower course; now we will tether our mustangs, put our fishing-gear into working order, and commence work.

The flies we must use are small, and of bright, gaudy colours. My first cast results only in a rise; my second is attended with better success—a fine speckled trout, the Oregon-brook trout (*Fario stellatus*) lies flapping on the grass. The next throw is into a comparatively still pool; with a gentle splash a small fish seizes the fly, and finds itself suddenly in the hands of a naturalist; I examine it carefully, and discover that I have a charr; more than this, it was a female fish, and she was full of eggs, others were soon taken; but in all the roe and milts were near to maturity, the largest charr did not exceed six inches in length, and there could be no doubt the fish were adult, and fully grown. I had frequently fished in the lakes on Vancouver's Island, as well as in other lakes and streams (I may mention the Sumass, Chilukweyuk, and Sweltza, as examples; these are mountain lakes, with streams flowing out from them), at lower levels along the spurs of this, the Cascade range of mountains; but in no single instance did I ever catch a charr.

The three lakes I have named fulfil every condition of the Cumberland, Swiss, and other lakes in which our charr (*Salmo salvelinus*) are usually taken, and one would have naturally supposed that if charr were to be found at all, they would have been in localities similar to those they favour and frequent in other countries. Not so, however; here is the only place (as far as my experience goes) where charr are to be obtained in British Columbia. The first thing which occurs to us as being unusual as regards this charr is, that there is no lake, nor even still water, near to where it resides, and not far above the spot on which we are standing, is the source of the river (about 7000 feet above the sea level), owing its origin to the melting snows, of course the water is at all times intensely cold. In the second place, we have tracked the river courses from the sea, and it is quite clear this tiny charr could never have come from the lower part of the river; it must have quitted its egg near to where I caught it, and have lived there to a mature age, and in its turn is now ready to deposit eggs for the production of another family. Even supposing this small and delicate charr risked a plunge over the cascade we peeped at, and survived the tumble, it is hardly conceivable that it would escape the thousand and one dangers which would beset it; and if it did, by no possibility could it ever return again to this part of the river. In the third place, the habit of leaving the lakes at the spawning time common to all our charr (according to Yarrell) can never be indulged in by this British Columbian species, because it is completely imprisoned in a few miles of river. The barrier on one side is a waterfall; on the other the source of the stream.

The stomachs of all the charr I opened were crammed with the remains of winged insects, and in a few of them I observed portions of the wings, together with other parts of the larger dragon-flies (*Eshna*), an insect that in size nearly equalled its devourer. I did not see any remains of aquatic larvæ intermixed with the other contents of the stomach, hence I am disposed to think these charr during the summer take the greater part of their food on the surface of the water. They are the most greedy little gluttons conceivable, I could see them dash at my flies two or three at a time, fighting and struggling to get the first chance to seize it.

The British Columbian charr is a particularly handsome little fish. The body is more slender than is that of the trout, and in colour olive-green, blushed with pink; the sides are densely covered with minute white spots, as if the fish had been sprinkled with whitewash; all the fins are of a pinkish hue, whilst the fish is alive, but turn to a dingy white immediately after death. The lower jaw being a little shorter than the upper, gives the head and snout (if I may use the word for want of a better) a snubby appearance. As the eggs of the female fish were nearly mature, there can be but little, if any, doubt that these charr spawn in August, although I had no opportunity to watch them as to their modes of depositing the eggs; and, singular to say, I never obtained a male fish. It is a somewhat remarkable difference, as regards the *Salmonidæ* of North-western America, when compared in habits with our own, that the former spawn in summer and early in the autumn, whereas our salmon generally deposit their eggs in December. But then we must not forget that during the summer the North-western rivers are at their highest, from the enormous inflow of water caused by the rapid melting of the snow, and also that the temperature of the water is never, in the hottest weather, more than a degree or two above the freezing point. If the salmon did not ascend the rivers during the flood time, they could not leap over the falls, or twist their way against the rapids, that everywhere occur to intercept their progress towards the spawning grounds. What are obstructions only when the rivers are high, become impassable barriers when the waters are at their lowest level.

There is another curious feature in the habits of North-western American salmon, one is at once struck with, which is, salmon never take a bait of any kind after quitting the sea; whereas their near relatives, the charr, trout, and salmon-trout, greedily take anything offered to them. My own opinion is, that the salmon in North-western rivers never feed after they abandon the salt water until they either perish or again reach the ocean, and I say, without fear of contradiction, that four

out of every six salmon die which ascend the river for the purpose of spawning in its tributaries. So vast, during the winter months, is the accumulation of dead salmon in the small streams, that to live anywhere near to them is next to impossible. Rotting fish hang from every spray that dips into the water; rotting fish lodge in every eddy, and jam against the irregularities of the rocks and boulders; rotting fish lie stranded on every sand-spit; and rotting fish are day and night drifting onwards towards the sea. Why such a waste of valuable food is permitted by the all-wise God who bountifully sent it, no one can tell; but that it is intended to serve some wise and useful purpose, although to us inscrutable, is indisputable.

To return to our little charr, it is equally puzzling to me to account for the presence of this member of the *Salmonidæ* in a mountain stream, shut in betwixt two barriers, and, as far as I know, it is not to be found in any other part of British Columbia. I am almost afraid to venture a suggestion, lest some geologist pounce down upon me. It is disagreeable, to say the least of it, to find oneself tumbled over, and sent floundering amidst the fragments of a pet theory, by some person who happens to be more learned in matters geological. I have my own opinions, however, and I mean to state them, and if I am snuffed out and utterly extinguished, so to speak, then so be it; there must be a right side and a wrong side to this question as there is to every other, and if I am groping my way along the latter, why the sooner somebody comes to the rescue the better.

I cannot help thinking this isolated charr might possibly have lived in a lake at some remote period, the bottom of which, now high and dry, we rode across when we left Fort Hope. Upheaval of the land drained the lake of its water, and as the mountains were tilted up higher and higher, a few charr might have either followed up the course of this stream, then a tributary to the lake, or they may have been lifted up bodily by a sudden convulsion, such as caused the cliff of rock over which the stream now finds its way, and constitutes an impassable barrier to the ascent or descent of fish. The other charr, after the lake was drained, perished, it may be, suddenly; or if they escaped, have given place, during the course of ages, to some stronger race of fishes "in the struggle for existence." Only in this way can I account for so singular a case of isolation as shown us in this British Columbian charr. Bearing upon, and in some degree, too, confirmatory of this theory, is another fact. Near by this stream wherein the charr live, rhododendrons grow, and in no other part of the Cascade Mountains were these plants discovered. How, then, can we account for this? Here we find a group of flowering shrubs completely islanded, if I may so express it, on a small spot of

ground in the very midst of a vast mountain-range. I can see no other way to solve the problem save that of admitting that some geological change has so modified and altered the general conditions requisite for the growth of this plant in the surrounding district, as to cause its extinction, whereas the small spot of land on which it thrives remains unchanged.

Perhaps I had better stop my theorizing, lest I get inextricably entangled. "Fools rush where angels fear to tread," says the adage. Dr. Gunther for some time imagined the specimens of this charr, which I brought home to the British Museum, to be the young of one of the species of salmon common to the rivers of British Columbia; and it was not until he examined them carefully, and discovered the fish were females containing fully-matured eggs, did he decide they were charr, and the smallest known species. In compliment to the discoverer, Dr. Gunther has named the new charr *Fario Lordii*.

I have given briefly a sketch of the general features of the Fraser River, the stream in which I caught the charr, and of the district through which it flows. How far my speculations as regards this fish's isolated position may accord with the opinions of those more conversant with the changes which have from time to time altered the earth's surface than I am, I do not know; of the charr itself I have not deemed it necessary to say more than was sufficient to put any reader in possession of its most prominent characteristics. Minute descriptions of structural peculiarities, by which it was known to be a species new to science, would prove anything but amusing, and of no practical value to any but the scientific ichthyologist. My end was to place its habits, and the singularity of its position, in a pleasant guise, for I fully believe the general reader, though looking upon a fish as only a fish, feels a pleasure in knowing what it does, and how and where it lives in far away lands. Whether or not I have succeeded in my endeavour my reader must decide.

PARASITICAL PLANTS.—THE BALANOPHORACEÆ.

BY JOHN R. JACKSON,

Curator of the Museum, Royal Gardens, Kew.

(*With a Tinted Plate.*)

THE structure and habits of parasitical plants are so peculiar and anomalous to those of other branches of the vegetable kingdom, that they have not only claimed the particular attention of learned and acute observers, but are also of great interest to all lovers of nature; indeed one of the most popular plants, the mistletoe, belongs to this class, as well as the largest known flower in the vegetable world, namely, that of *Rafflesia Arnoldi*. It is to the class of parasites to which the *Rafflesia* was formerly considered to be allied—the *Balanophoræ*—that we wish to direct the reader's attention; *Balanophoraceæ Cytinaceæ*, and *Rafflesiaceæ* were included by Lindley under the head of *Rhizanthæ*, which constitutes one of his five divisions of the vegetable kingdom. The plants so classed are all destitute of true leaves, but having instead cellular scales they do not partake of any of the appearances of other plants, having no indication whatever of green colouring matter about them, but are either brown, purple, yellow, or a pale, livid pink. They have short amorphous stems; that is, they are without regular or definite form, and are always parasitical on the roots of other plants. They have true flowers, with stamens, pistils, etc., but these flowers vary considerably in their form and structure; so much so, indeed, as to induce some botanists to consider them widely distinct, and to place them widely apart in botanical classification. Dr. Hooker is of opinion that the *Balanophoræ* have no affinities whatever with *Rafflesia*, but are nearly connected with *Haloragaceæ*, to which the Trapás belong.

Numerous papers have been read from time to time at the various learned societies both here and on the continent, on the structure and affinities of the various genera and species of the *Balanophoræ*, but no one has devoted so much attention to the whole group as Dr. J. D. Hooker, the present Director of the Royal Gardens, Kew, who by the aid of his extensive correspondence, as well as by his own travels, has secured an unrivalled collection of these peculiar vegetable forms for the Kew Museum.

These plants rise not more than a foot above the ground. They are all natives of hot countries, in the tropical and subtropical mountains of Asia and South America, where they

probably occur in nearly equal proportions. The rhizome, or rooting portion of Balanophorous plants is usually in the form of a simple or branched tuber, seated flat upon the root of the plant, to which it is attached. In very young plants the appearance is nothing more than a mass of cellular tissue, united with the tissue of the root. Dr. Hooker says, "It offers at first no trace of a vascular system, nor any distinction of parts, but before it has reached the cambium layer of the bark, and before its upper extremity has attained any considerable size, an opaque line of white cellular tissue, different from the rest, may be found in the centre of the mass, or beneath each of its lobes, in which vascular tissue makes its appearance. Shortly afterwards the wood of the root upon which the parasite grows appears to become affected, its annual layers are displaced, and at a still later period vascular bundles, enclosed in a cellular sheath, are found in the axis of the rhizome, and are continuous with those already found in it. Some genera do not present the appearance of any vascular bundles communicating with those of the root stock, but their own vascular bundles may be traced descending to the line of union between the root and the parasite, where they become closely applied to the vascular system of the former, without, however, forming any interlacement or organic union."

The roots or rhizomes of these plants are of comparatively slow growth, but vary much in the several species. This may in some measure be referred to the different forms of attachment or union with the roots upon which the parasites grow, for it would appear that there are three distinct modes of attachment in the several distinctive forms or genera, and these have been suggested as lines by which to divide the *Balanophoræ* into three sections; firstly, where the vascular tissue of the parasite and nourishing plant is apparently merged in one, or continuous; secondly, where the attachment is alone effected by means of the cellular system; and thirdly, where the termination of the vessels from the root into the parasite are definite or distinct. The most perfect examples of the first of these divisions are to be found in the genera *Rhopalocnemis* and *Balanophora* itself, where also the most perfect vascular system exists, the woody tissue being present throughout the whole plant. Fig. 1 shows a transverse section of *B. involucrata*. The formation of the tissue in *Helosis Mexicana* illustrates the second division, Fig. 2; while that of *Langsdorffia* illustrates clearly the third, Fig. 3.

In the cellular tissue of many of the *Balanophoræ*, wax is secreted in large quantities. A view of one of these cells, burst open, and discharging its waxy granules, is shown at Fig. 4. The wax is found mostly in *Balanophora* and *Langs-*

dorffia, while in *Lophophytum*, *Cynomorium*, and *Sarcophyte* in particular, as well as in other genera, starch grains are found in the place of wax.

The plants are either monœcious or diœcious. The flowers in some species are arranged in a capitulum, or head, varying in shape, being either round, oblong, ovoid, etc., and in other species they are in compound spikes or panicles. The individual flowers also vary considerably in the different species; they are most perfectly developed in *Mystropetalon*, and the least so in the female of *Balanophora* and the male of *Lophophytum*. The flowers are either with or without a perianth, but when present it is usually dimorphous. In the genus *Rhopalocnemis* it is tubular, while in *Thonningia* it is composed merely of three very minute scales. The styles, stamens, etc., are very variable in number, as well as in form, but though they are always present, they are in many species so imperfectly developed as almost to warrant a very low position in the arrangement of flowering plants; but, on the other hand, "if we disregard imperfection, and inquire what organs are wanting in the order, we shall find that, with the exception of terrestrial roots, all are present which are necessary to justify their being placed among phænogamic plants."

Of the whole of the genera of the *Balanophoraceæ*, *Mystropetalon* is the most perfect, or highly developed. In the capitulæ, or flower-heads of this genus, the male flowers are always seated at the top, and the female flowers below. This does not occur as a rule through the other genera, the males in many instances being lowest. *Cynomorium coccineum*, Michx. is the *Fungus melitensis* of the old writers. From its old name one might be led to expect that it is alone indigenous to the Island of Malta, but its range extends to the Levant, the Canary Islands, and Northern Africa. The plant grows to about a foot in height, it has a deep pink or reddish tinge, and a very fleshy appearance. The flowers are unisexual, but sometimes hermaphrodite flowers are likewise found on the same head. The parts of the perianth, or floral coverings, are always in sixes. The whole plant is covered with small scales. This plant was formerly much valued in Malta as a medicine for the cure of dysentery, and the places where it grew were carefully guarded to prevent its being stolen. The plants were, even up to a recent date, protected and gathered under the supervision of an officer appointed by the British Government. They formerly had a great reputation for stopping the flow of blood, and it is said that the celebrated styptic used by the Crusaders to stanch their wounds was none other than this plant. Mr. P. B. Webb, who travelled in the Canaries, tells us that it is eaten for food there, and much esteemed. Of the genus

Sarcophyte, S. sanguinea, Sparrm. is the only species known. It is found only in South Africa, principally on the roots of species of Acacia. The male flowers are panicled, but one of the characters by which this genus is distinguished from *Balanophora* is that the filaments and connectives of the stamens are free, while in *Balanophora* they are united. The male flowers have a three-lobed perianth, and the female flowers are arranged in globose heads, and have no perianth. The arrangement of the tissues in the stem of *Sarcophyte* do not differ essentially from other species of the order, though in the peduncle the vascular bundles are very irregularly deposited. The roots of the plant upon which it grows are connected by stout, woody branches with the rhizome of the parasite, and there seems to be a complete fusion of the vascular tissues of both. The stems of *Sarcophyte* contain innumerable starch granules.

Two species are enumerated of *Langsdorffia, L. hypogæa,* Mart., and *L. rubiginosa,* Wedd., but Dr. Hooker, who is undoubtedly the best authority on *Balanophoræ,* doubts whether there are sufficient characters to distinguish the latter from *L. hypogæa.* They are both natives of South America, the first being distributed through Mexico and Brazil. The remarkable parasitism of *Langsdorffia,* Dr. Hooker describes in the following terms:—"The dichotomously branching rhizomes appear most frequently to corrode, as it were, the back of the roots they encounter, which they even sever, and then enclose the end that remains attached to the parent plant. The root swells considerably at the junction, and appears to send prolongations of wood into the rhizome of the parasite, which run along its axis for several inches, and though there is an intimate union between the wood of the root and the cellular tissue of the parasite, there seems to be no blending of their vascular systems." The fruit-bearing receptacle after flowering dilates very much, which causes the scales to spread open, and when fully expanded the whole has a similar appearance to the involucre of a thistle (Fig. 5). The rhizome of this species is highly charged with wax, and it will burn freely with a clear flame. The secretion is contained entirely in the cellular tissue where it appears as a large opaque mass in every utricle. This wax is collected to a large extent by the people of New Grenada, who make candles of it, while in Bogota the stems themselves are collected and sold in all the markets without any preparation, for use as candles on Saints'-days. On the Tolima range of mountains around Bogota the plant is known by the names of "Belacha" and Melonsita, and the soft receptacle, when ripe, is eaten and considered stimulating and refreshing.

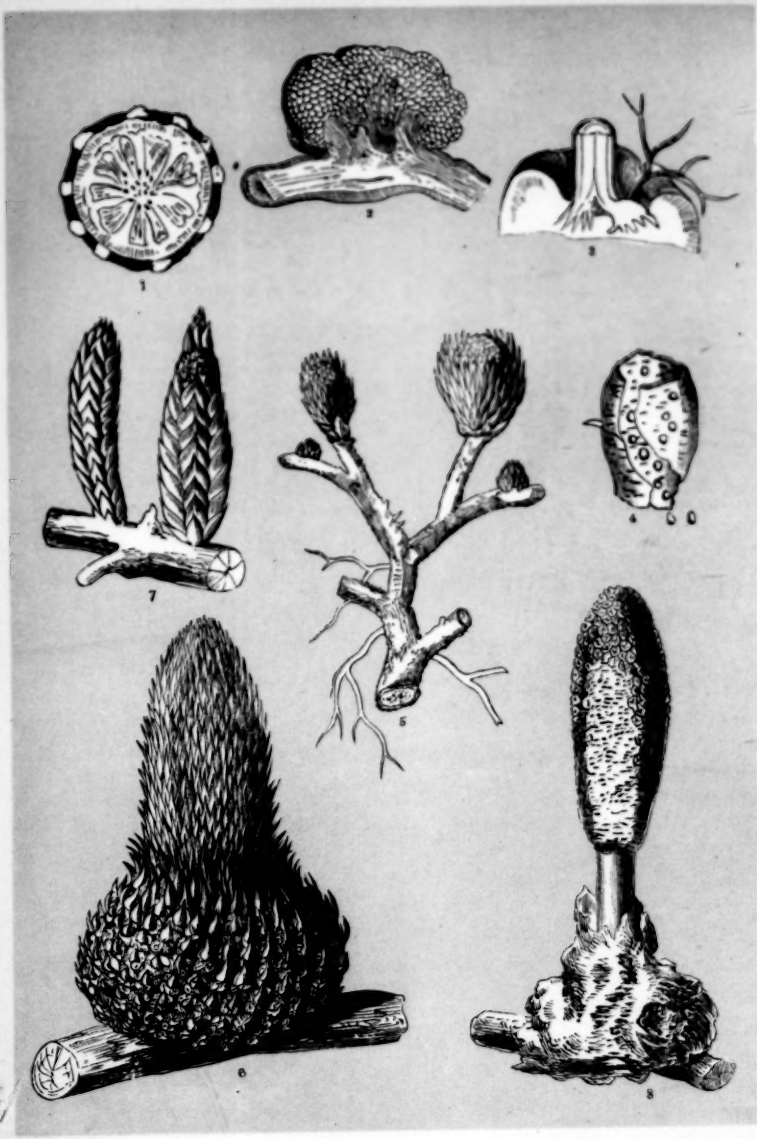
Thonningia sanguinea, Vahl., is found in Western Tropical Africa, on the roots of trees. Its root-stock is of a dingy

brown colour, and the flower-stalks are covered with closely-imbricated scales of a bright red colour. The only difference between the female flower of this plant and that of *Langsdorffia* is that in *Thonningia* it has a more complete tubular 3—5 toothed perianth, the stamens are united into one column, at the base of which are a few scales. Specimens of these plants were first brought to Europe by Thonning in 1804, Vahl examined them, and described the genus, naming it after its discoverer. So far as is known they have no economic uses.

Of the genus *Balanophora*, eight or nine species are enumerated, but in bringing them down to this number, some varied forms or varieties are included as one species. Quoting Dr. Hooker upon this point, it appears these varieties are so numerous that neither colour, form, nor the sexuality of the capitula are constant characters. In the same woods wherein the Doctor gathered *B. involucrata* var. *gracilis*, growing upon the roots of oak, he also gathered var. *flava*, growing on those of an Araliaceous shrub, and differing from the var. *gracilis* only in its more robust habit. *B. involucrata*, Hook. fil, grows in the Himalayas at an elevation of from 7000 to 9000 feet. It is, however, common in Sikkim up to 8000 or 10,000 feet. The capitula of this species, as well as the stalks, are of a very bright colour, either red, a rich deep crimson, a brightish yellow, or of a purplish tinge.

Balanophora dioica, Br., *B. indica*, Wall., and *B. polyandra* are all East Indian species. The first is very common in Eastern Himalaya and Khasia, and is also very variable in form, according to the localities in which it is found. "Specimens of all sizes may be found, from an inch to a foot high, of all degrees of robustness, and of all colours between blood red, yellow and white, or brown." *B. polyandra* is very abundant on the Khasian and Himalayan mountains, at an elevation of from 4000 to 6000 feet. It varies from two inches to six inches in height, and differs from some of the other species in having the capitula always short and sub-cylindric or conical, but like *B. dioica* it varies much in colour and robustness. It flowers during the months of August, September, October, and November.

B. elongata, Bl., is an inhabitant of the mountains of Java, where it is found at an altitude of from 5000 to 9000 feet. It is also found in Ceylon, and on the mountains of the East Indian islands. It has been found in flower in the months of March, May, and August. *B. globosa*, Jung., is found in Burmah, and *B. alutacea*, Jung., in the Philippine islands. They both flower in April. The first of these two species in general habit much resembles *B. indica*. The rhizome has a peculiar, crumpled appearance, covered with small tubercles, or



BALANOPHORACEÆ.

1. Transverse section of rhizome of Balanophora involucrata. H.f.
2. Vertical section of Helosis Mexicana, shewing its attachment to the root.
3. Vertical section of Langsdorffia rubiginosa, shewing its attachment to the root.
4. Single cell from cellular tissue (magnified.) shewing wax globules.
5. Portion of a plant of Langsdorffia rubiginosa.
6. Plant of Lophophytum Weddellii. H.f.
7. Male plant of Phyllocoryne Jamaicensis. H.f.
8. Male plant of Rhopalocnemis phalloides. Jung.

warts. The whole mass appears highly charged with wax. Wallich says that it is sold in the Burmese bazaars for medicinal purposes.

B. fungosa, Forst., is peculiar, as being the only Australian species. The following description of the arrangement of the tissues in this species is so clear that we cannot do better than quote it entire:—"The most curious point in this species is the tendency of the tissues forming each vascular bundle in the rhizome to arrange themselves rudely into the form of an exogenous stem, the wood forming a zone of wedges round a central pith, enclosed by a cellular zone that communicates with the pith by broad medullary rays. The total absence of pith in the root, with whose wood these bundles communicate, would thus seem to indicate that the wood of the rhizome belongs to itself, though it has all the appearance of being solely produced by the root; the root, in short, supplies the nutriment from its own vascular tissue, but the parasite organizes it."

The several species of *Balanophoræ* are found on the roots of such trees as oaks, maples, vines, etc., but *B. involucrata* has also been found growing on the exposed aërial rootlets of oaks in damp or humid forests. This species, when growing upon subterranean roots, appears to affect them much more than any other, as it produces large knots from two to four inches in diameter. These are much prized by the natives, who make from them very neat wooden cups, which are in general use throughout the Himalaya and Thibet. Some of them are esteemed antidotes for poison, and for this purpose fetch a high price. This and the Java species, *B. elongata*, which furnishes a wax from which candles are made, are the only species of any importance in an economic point of view. In *Lophophylum Weddellii*, Hf., the root-stock is a somewhat spherical fleshy mass, covered on the upper part with long overlapping scales. From the top of this mass springs the flower-stalk, very much in the form of a pine cone, and covered likewise with imbricated scales. On the upper portion of this stalk small regular branches are given off, upon which the flowers are closely packed. A better idea of this singular plant will be obtained from Fig. 6 of the plate. It is a native of New Grenada, in moist woods. It is said to be used by the natives as an article of food. Two other species have been described, viz.:—*L. mirabile*, Schott and Endl., and *L. Bolivianum*, Wedd. Both of these are South American, the first being found in Brazil, the other in Bolivia.

Ombrophytum Peruvianum, Pœppig and Endl., is another of those peculiar plants which Pœppig has described as being eaten by the Peruvians, who boil it, and treat it similar

to fungi. The generic name is derived from the Greek, *ombros*, a shower, and *phyton*, a plant; in reference to the sudden way in which they are said to spring up after a shower of rain. The genera *Scybalium* and *Sphæronhizon* follow here in the order of classification. *Scybalium fungiforme*, Sch. et Endl., a native of the forests of Brazil, being the only described species of the first genus, and *Sphærorhizon curvatum*, H. f., the only species of the second. This plant, from the fact of its roots penetrating only the last year's wood of its prey, and producing no effects in the layers below, would seem to be only of annual duration.

Phyllorcoryne Jamaicensis, H. f., is found in the savannahs of Jamaica, as its specific name indicates. It is the only West Indian species, and is commonly known in Jamaica as John Crow's nose, but whence the derivation of such a singular vernacular we are unable to tell. The plant is found in flower from January to July. The rhizome or root-stock is branched or lobed, a transverse section of which shows "a thick brown cellular cortical layer, formed of hexagonal cells full of starch granules and chlorophyll, with occasional masses of hard, woody, or sclerogen cells." From this root-stock numerous flower-stalks arise, covered all the way up with closely imbricating scales. These flower-stalks bear large cylindrical or oblong flower-heads. (Fig. 7).

Rhopalocnemis phalloides, Jung., is undoubtedly the most noble, if we may so speak, of all the *Balanophoræ*. It is found at the roots of trees in the mountains of Java, at an elevation of 7000 feet, as well as in the Khasian and Himalayan mountains, Nepal and Sikkim, at 6000 to 8000 feet. It grows in shady woods in large masses, and has a very pretty appearance, with its pale yellow brown heads only showing above the ground. The rhizomes are of various sizes, from that of an egg to masses as large as the human head. The flower-buds, which spring from the rhizome in their earliest state, appear like swellings, which presently burst forth and reveal the most magnificent flower-heads. "Both males and females expand at the same time, throwing off their cohering bracteal scales in large masses, and exposing a velvety pile of style, and a dense mass of subjacent articulate threads. There are several crops of male flowers which expand successively, and in the dense humid woods in which this genus grows, insect agency is probably necessary to impregnation." A representation of this plant will be found at Fig. 8.

Three species of *Corynæa* are enumerated, namely, *C. crassa*, Hook. fil, *C. sphærica*, H. f., and *C. Purdiei*, Hook. fil. The first of these is the most imposing plant of the three, frequently weighing many pounds. It attacks the roots of its prey in all

directions, swelling over stems, and completely encircling them. It has a thick, fleshy flower-stalk and dense flower heads; the male flowers much resemble those of *Rhopalocnemis*, it is a native of New Granada, at an altitude of 8000 feet. *C. sphærica* is also a New Granada species, and is found at a similar elevation. Like the former, the rhizome completely encircles the root of its prey; though the plant itself has a very different appearance to *C. crassa*, the flower heads are more globular and regularly formed. *C. Purdiei* is a native also of the same country, growing chiefly on the roots of *Cinchona*. The capitula and the flowers themselves are very similar to those of *C. sphærica*.

Helosis Guyanensis, Rich., is a very remarkable plant, and has been described and written about by several illustrious botanists. It is found in Guiana, as its specific name indicates. Its range, however, appears to be in "damp woods on the East coast of South America, from Trinidad to south of the equator." The rhizome, or root, runs underground for a great distance, adhering to any roots which come in its way. Dr. Hooker has shown that the arrangement of the tissues in a transverse section of this rhizome closely resembles that of many menispermaceous plants, and that the vascular system of the peduncle consists of scattered bundles that run free, and unbranched from the rhizome to the capitulum, where they partially anastomose, forming a plexus within the circumference, from which bundles are given off with great regularity towards the base of each scale. The plants vary much in size from an inch to about a foot high. The flower-stalks are numerous, with globose or ovoid heads of flowers, the males and females being on separate heads. From close observation it would appear that the female flowers are seldom, if ever, fertilized except through insect agency. The native country of *H. Mexicana*, Lieb., is also indicated by its specific name. It is found on the Mexican mountains, at an altitude of 3000 to 5000 feet. It does not differ considerably in form or structure to *H. Guyanensis*, but it is not so variable. Plants of this genus are of little or no economic value, though they are sometimes used as styptics in their native countries.

Though the *Balanophoræ* are of no value or importance in a commercial or economic point of view, they are most interesting in a scientific point. Popularly little is known about them, or even of the existence of such plants. This is easily to be attributed to the fact that no living plants have been seen in this country, and they are certainly less attractive to a general observer in a dried state than when arrayed in their bright colours. But even with a slight acquaintance of their habits and modes of growth, they cannot fail to excite some interest.

PHASES IN THE DEVELOPMENTAL HISTORY OF INFUSORIAL, ANIMAL LIFE.*

BY JABEZ HOGG, F.L.S., F.R.M.S., ETC.

THE elucidation of the mystery which surrounds the beginnings of organic life, and the discovery of the living principle which exerts so powerful an influence on all animated creation, has often and long been sought for by philosophers as well as physiologists, from the earliest ages down to the present time; but all their efforts have been in vain, and we stand in precisely the same position in regard to this subject as that occupied by the first philosopher who entered upon its investigations. Although we have not been able to throw much light on the nature of life, we find that the degree of vitality possessed by an animal is to a great extent in proportion to the degree of its organization, and we may conclude from this that there is an intimate connection between life and organization. Not that organization can create life; of this we have no instance at all, but that the principle of life, which exists in and has been given to any organic germ is only brought to maturity in accordance with the original law of its organization; and by means of this *principle of life* it is enabled to pass into a state of greater perfection, constituting what has been called, and is now recognized as the *law of progressive development*. First, let me say that I do not purpose to enter upon any inquiry into the precise nature of life, such as I have just hinted at, but rather let me on this occasion direct attention to some points of interest in the developmental history of infusorial life.

On the threshold of this inquiry a remarkable theory, and one which cannot be passed over without discussion, stares us in the face, "Whether among the smallest, and apparently the most elementary forms of organic life, the phenomenon of spontaneous generation obtains?" This question has quite recently formed the subject of careful experiment and animated discussion on the continent; the *general* opinion, however, seems to be that the lowest forms, in common with the highest, are generated by reproduction from preceding forms.

Aristotle found no difficulty in believing that worms and insects were generated by dead bodies; and to the mind imperfectly acquainted with the results of modern investigations, spontaneous generation is as easy of belief as it was to Aristotle.

* Being the substance of a lecture delivered to the Old Change Microscopical Society, September 27th, 1866.

Do we not constantly see vegetable mould covering our cheese, our jam, our bread? Even our air-tight vessels cannot be kept free from plants and animals, where neither plant nor animal could be seen before, and where it appears impossible that their seeds could have penetrated. Where do those parasitic animals come from which are to be found in the blood, the brain, the liver, and the eye? How got they there? These questions are more easily answered on the supposition that generation can take place spontaneously; nevertheless, the weight of scientific evidence has been year after year accumulating against such a supposition, and the majority of physiologists have come to the positive conclusion that no generation whatever can occur except by direct parentage.*

And yet how difficult at times to divest the mind altogether of some such theory, when asked to account for the apparently sudden appearance in a most unlikely place, of some such extraordinary creature as that of Mr. Crosse's *acarus*. This, as you are aware, was found in a solution of silicate of potash, through which an electric current was passing, and after every care had apparently been taken to free the apparatus from every particle of dust and foreign matter; or that noticed by Dr. Maddox on the surface of a nitrate of silver bath, which had been set by for some time. The several bright spots in motion proved to be well-developed, highly-organized acari, looking like "miniature fat sheep."†

These, and other like remarkable instances were at one time regarded as good evidences of spontaneous generation, and afforded a simple and easy mode of getting rid of a difficulty.

The first formidable assailant of the doctrine of spontaneous generation was the celebrated Italian naturalist, Redi. In his work *On the Generation of Insects*, he proved that the worms and insects which appear in decaying substances, are really developed from eggs designedly deposited there by the mature animal. But it was thought preposterous to suppose that putrefaction could produce an insect, and this explanation was for a time rejected. But driven from the insect world, where such an hypothesis could have no chance of success, the upholders of it sought refuge in the world of infusorial and parasitic life.

Any one acquainted with the writings of Leuwenhoek will see how steadily this father of microscopy set his face against spontaneous generation, because even his imperfect instrument showed him that many of the most minute animals produced eggs, and were generated like the larger ones. Since his time

* Lewes.

† *Quarterly Journal of Microscopical Science*, vol. ii. p. 96.

hundreds of observers have brought their contributions to the general stock, and the modes of development of plants and animals have been more and more clearly traced; and each extension of knowledge in this direction has had the effect of narrowing the ground on which the spontaneous hypothesis could possibly find a footing; and the question now comes to this: "Is it more probable that a law of generation which is well nigh universal in the organic world, should have an exception; or that our researches have as yet been so faulty that we have not as yet been able to bring this seeming exception under the law? One after another, cases which seemed exceptions have turned out to be none at all. One after another, the various obscurities have been cleared away, and it is therefore the dictate of philosophic caution which suggests that so long as we remain in positive ignorance of the actual process, we must assume that a general law prevails."*

Positive evidence would at once settle the dispute, and I take this opportunity of directing ardent and aspiring microscopists to the question, as one well worthy any amount of time and trouble; but I must tell them beforehand that every one who has hitherto made any experiments, or attentively followed those of others, has found it exceedingly difficult to devise any experiment which shall be conclusive. This arises, first, because the facts elicited admit of very different interpretations; and secondly, from numerous sources of error. "For it is quite true that there are organic beings of which we can as yet only say that there is the strongest presumptive evidence against their being exceptions to the otherwise universal law to which I have alluded. As an instance, we do not know how the *Amœba* arises, no one has even seen its eggs, or ever been a witness of its mode of reproduction; and yet we find the *Amœba* in almost every drop of rain-water, and most vegetable infusions, so that we may be perfectly certain that its ova are carried about by every breath of air." Schultze, of Berlin, devised an experiment which might have been thought to settle the question. This experiment proved that an infusion of organic substance, supplied with air driven through a strong acid, could be suffered to remain for three months without either any animal or vegetable life becoming apparent. At the end of that time atmospheric air was allowed to enter freely, and in three days the infusion was found to be swarming with animalcules.

It will be at once observed that the essential condition in such an investigation is to be quite certain that no organic germs are introduced into the liquid from without, and that there should be secured a free supply of air, carrying no

* Lewes.

organic germs; on the hypothesis that animalcules, like other animals and plants, are produced from germs or eggs, which might be in the water and yet so excessively minute as to be easily overlooked, and only awaiting the proper *conditions* for their speedy development; or, on the other hand, supposing them to be floating about in the air, they would fall into or enter any vessel containing organic matter in a state of decomposition and there develop. Schultze's experiment, then, looked very like a conclusive one, for no sooner were measures taken to destroy the germs, supposed to be suspended in the air, than the infusion was kept free from animalcules; and no sooner was the air allowed to enter in the ordinary manner than both animal and vegetable life abounded. It was thought, however, by M. Morren, that air in its passage through sulphuric acid underwent some alteration which affected its power of supporting life; and upon putting this to the test, he found that air passed through sulphuric acid was incapable of sustaining life. We have then, M. Pouchet's experiments, which are of a most imposing character. He announced that there was nothing in either Schultze's test or Morren's correction, for he declared that in following the former's experiment in every particular, and also in repeating it with fresh precautions, he could constantly find both plants and animals in an infusion in which every organic germ had been previously destroyed, and to which the air only had access after passing through concentrated sulphuric acid, or through a series of porcelain chambers kept at a red heat. M. Pouchet even goes farther than this. He determined to substitute for atmospheric air, *artificial air;* this he introduced into a flask containing an infusion of hay, the *hay* having previously been subjected for twenty minutes to a heat of 212° F. He thus guarded against the presence of any germs in the infusion or in the air. The whole was then hermetically sealed; but in spite of all these precautions, both plants and animals appeared in the infusion. He repeated the experiment with pure oxygen gas instead of common air and with similar results.

Professor Wyman instituted a series of thirty-three experiments, prepared in different ways, in which solutions of organic matter, some of them previously filtered, having been boiled at the ordinary pressure of the atmosphere for a length of time varying from fifteen minutes to two hours, were exposed to air purified by heat. In only four were the contents of the flasks unchanged when opened; in all the rest *Bacteriums, Vibrios, Ferment-cells, Monads,* or *Kolpoda-like* bodies were seen, some of them having ciliary movements. In nearly every instance their presence was indicated by the formation of a film, which appeared in some, on the second, and in others not until the

nineteenth day. The result of these experiments is, that the boiled solutions of organic matter made use of, exposed only to air which has passed through tubes heated to redness, or enclosed with air in hermetically sealed vessels, and exposed to the heat of boiling water, became the seat of infusorial life; but such experiments throw no light on the immediate source from whence the organisms in question were derived. I have shown repeatedly, as well as numerous other observers, that the air contains many kinds of organic matter, spores of cryptogams, starch granules, and other vegetable fragments, and probably also the eggs of many animalcules, all of which are floating freely about.

Milne-Edwards objected to the conclusions of Pouchet, saying, there is no proof that the hay itself had been subjected to the temperature of boiling water, it being very probable that although the furnace was at that heat, the hay, which was in a glass vessel and surrounded with air at rest, was not at anything like that temperature. On the other hand, granting that the temperature may have been reached, that would not suffice for the destruction of all the germs if they were perfectly dry; the power of resistance possessed by vegetable silicated cylindrical tubes, as hay and straw, is well known. The observations of M. Doyere prove that the *Tardigrada*, "water-bears," when thoroughly desiccated, preserve the power of reviving even after having been subjected to a temperature of 316° F. The *Vibrio tritici* will maintain its vitality for many years through all the vicissitudes of heat and cold. I have kept wheat for ten years, and still find these animals easily resuscitated; and Mr. Deane mentions a remarkable fact, "that on a particular piece of land whenever wheat is grown it is always infested with *Vibrio*, no matter what the length of time since the previous wheat crops, nor what crops have been sown in the meantime." If, therefore, animals of so complex a structure as these *Tardigrada* and *Vibrios* can resist the action of time and temperature, there is no reason for supposing that the germs of the simpler animalcules would be destroyed by them.

The Rev. Lord Sidney Godolphin Osborne, in a letter filled with interesting remarks on "Cholera and its germs," which appeared a few weeks ago in the columns of the *Times*, writes—"I know from experiment that there are 'germs' containing a principle of life, that will stand very strange usage, and yet not have that principle destroyed. Many years since I applied a certain matter to a piece of glass about four inches square. This has another very thin piece cemented close over it on three sides, leaving a space just sufficient for a thin stratum of water between the two. It has been exposed for days to

the action of the direct rays of the sun, it has been kept in the dark, and sometimes has been for a year or two in a very dry place without a particle of water touching its surface. To amuse friends I have again and again allowed a little water, sometimes filtered, generally of the coldest *spring* nature, to fill up the space between the two glasses—water I had previously tested for any living organisms. I have never failed to produce, in a few hours, a most beautiful exhibition of one of the most interesting species of Infusoria, having beforehand sketched the exact creature I would produce. With the same water, in another glass tank of the same nature but not so prepared, I fail to produce anything at all until it has been left for some days, and then the creatures seen are not my old friends. I have read, not seen, that these organisms retain their vitality even when the glass has been made red hot. I don't say I believe, but from what I have seen I think it quite possible."

I have myself found, upon subjecting the spores of *Penicillium* to the action of boiling water, twice over, that they remain uninjured, their vitality is so little impaired that on placing some of them in saccharine solutions and other substances, carefully excluded from the air, a very short time sufficed to show the presence of the characteristic mould growing up from the spots where the spores rested, and microscopic examination confirmed the character of the growth.

M. Quatrefages says, that he examined the dust remaining on the filter after ignition from some observations on rain-water, and found that the organic elements presented a confused assemblage of particles, and this continued to be the case for a few minutes after their immersion in water; but in a few hours he detected a great number of vegetable spores, infusoria, and those minute spherical and ovoid bodies familiar to microscopists, which inevitably suggest the idea of eggs of extremely small size. He also declares that he has frequently seen monads revive and move about after a few hours immersion.*

M. Pouchet's reply is, that if the air is filled with animalcules and their eggs, they will, of course, fall into any vessel of water, and as water is their natural element, will there exhibit their vitality. But if half-a-dozen vessels of distilled water, perfectly free from animalcules, be left exposed to the air beside one vessel of distilled water containing organic matter in decay, the half-dozen will be free from animalcules and eggs, but the one will abound with them. Now it is perfectly intelligible that inasmuch as organic matter is said to

* Mr. Samuelson examined the dust shaken from rags brought from Alexandria, Trieste, Tunis, Peru, and Melbourne, and found in all germs of *Monads*, *Bacteria*, and *Kolpoda*.

form the indispensable condition for the development of the eggs, it is only in the vessel containing such matter that the eggs will develop; but why are they not also visible *as eggs* in the other vessels? Why are not the animalcules themselves visible there as they were in the water examined by M. Quatrefages?

My reply to Pouchet's question is, that in all the vessels ova had probably been deposited, but for lack of nourishment, in five, they had quickly died. It is well known that in all organized structures, disorganization rapidly sets in, unless either some vegetable matter or a well-oxygenated medium be ready at hand to carry the ova on to maturity. And as to their not appearing in all the six vessels, I can only say that this does not accord with my experience; for upon exposing any number of bottles to the same atmospheric influences, all have given positive results, and I can only suppose that M. Pouchet either made a very imperfect and cursory examination, or his microscopic manipulation must have been greatly at fault.

A few years ago an observation made by Cienkowski, the botanist, seemed finally to settle the question of spontaneous generation, and to place the matter beyond doubt, because it caught nature in the act, so to speak, of spontaneously generating. Cienkowski's statement is as follows:—If a slice of raw potatoe be allowed to decompose in a little water, it will be found, after some days, that the starch cells have a peculiar *border*, bearing a strong resemblance to a cell-membrane. This shortly turns out to be a real cell-membrane, and is gradually raised above the starch grain, which then occupies the position of a cell-nucleus. Thus, *out of a grain of starch a cell has been formed under the observer's eye.* Inside this cell little granular masses are developed, which begin to contract. Finally, minute eel-like animalcules (a species of *Anguillulidæ*) are developed there, which bore their way through the cell-wall into the water.

Franke, in his report of this observation, which he says he has verified, asks, "how is it possible to deny spontaneous generation here? Before our eyes a grain of starch becomes a cell, in that cell are developed living forms, which bore their way out." Again, Professor *Nægeli* stated that he had been baffled at first in the attempt to verify this observation, but that after nearly a hundred trials he had succeeded; he appears to have confirmed all the statements made by Cienkowski; but if the phenomenon was of such rare occurrence, surely there must have been some other explanation than that of spontaneous generation.

It seemed probable that error had crept in somewhere. Cienkowski himself at length discovered the source of his own

error: the membrane which seemed to form itself round the starch granule had quite another origin. He observed the little *Monads* swimming about, and noticed one of them adhere to a starch grain, spread its elastic body round it, and finally envelope it, just as the *Amœba* does its food. Thus was explained how the starch grain came to be inside a cell; and as this process was never suspected, and as the starch-grain was within a cell-wall, the idea of natural formation was inevitable, the more so as the wall seemed to grow larger and larger.

M. Pasteur, who has been the leading and most determined opponent of the spontaneous generation theory, contrived a series of experiments which met many of the arguments brought forward by Pouchet, and he thought it was possible to obtain, in some place, atmospheric air so pure that it would not produce any change whatever in a putrescible liquid. M. Pouchet, Joly, and others, in their desire to meet this idea, ascended the glacier of La Maladetta, in the Pyrenees, taking with them a number of flasks, each one third filled with an infusion of hay, which had been previously filtered and boiled for more than an hour. The air was then exhausted, and the flasks hermetically sealed. Four were then afterwards filled with air on the surface of the glacier, and four in a crevasse. The examination of four of the flasks, three days afterwards, gave specimens of *Bacteria, Monads, Vibrio, Mucidinea,* and *Amœba*. The conclusion drawn from this was that even the air of high mountains did not fulfil the conditions which M. Pasteur predicated of it. Nevertheless M. Joly said that he believed that M. Pasteur was quite right in his statement that all that was required for the production of animalcules was "air and a liquid susceptible of putrescence," and that in his opinion there is no such thing as "spontaneous generation."

M. Pasteur goes on to state that the doctrine of spontaneous generation may be expected to be constantly turning up, since it maintains a hold over us, unknown to ourselves, from its relation to the impenetrable mystery of the origin of life upon the surface of the globe. Gay Lussac's report of his examination of the method of preserving provisions for the army, was not without its influence on the minds of men on the subject now under consideration. He proved that when the air in the bottles in which substances have been well preserved is analyzed, it no longer contains oxygen, and consequently that the absence of that gas is a necessary condition for the conservation of animal and vegetable substances. He also found that grapes crushed under mercury do not undergo fermentation unless brought into contact with pure oxygen, or with common air, even in a scarcely perceptible quantity. Such experiments, made with so much exactness and care by so great a master of

chemistry, have never been disputed, and other observers, following in his footsteps, have extended their researches to the organisms which arise in vegetable infusions; and all, whether partisans or opponents of the theory of spontaneous generation, admit that the smallest possible quantity of atmospheric air is sufficient, when brought into contact with a suitable infusion, to produce in a short time such changes, that there appears an incredible number of minute forms of animal life. The character of the infusion most decidedly exerts an influence over the ultimate results; as for instance when any kind of albuminous material is added to the saccharine fluid, the spores of a fungus, *Penicillium glaucum*, cover the surface in a few days; the infusions are also affected by the atmospheric conditions, whether summer or winter, by locality, whether placed inside or outside the house, in town or in country.

To sum up, and in a few words, after having carefully considered the arguments used by disputants on *both* sides of this question, I believe I am perfectly right in saying that the balance of experiment is certainly very much against the spontaneous generation theorists; but so much has been said and written on this subject, that we might if space permitted, greatly extend our remarks. There is, however, another point deserving of notice, which appears naturally to follow an inquiry into the source of living organisms, namely, the order of their successive appearance in vegetable infusions. This point in the life history of the infusoria has already occupied the attention of many investigators: and one in particular I wish to direct attention to,—Mr. Samuelson, whose researches were carried on in conjunction with Dr. Balbiani of Paris, and confirmed by him. As might have been expected of this gentleman, he starts by asserting his utter disbelief in spontaneous generation, and then goes on to tell us that when a carefully prepared infusion of vegetable matter in distilled water is exposed to the air, the *Protozoa* which first appear in it are *Amœba*: these in a few days disappear, and are succeeded by ciliated infusoria, such as *Kolpoda*, *Cyclidium glaucoma*, and sometimes *Vorticella*, and these in their turn by what we have looked upon as higher forms, as *Oxytrichum*, *Euplotes*, *Kerona*, etc., consequently Mr. Samuelson thinks that *Monads* are but the larval condition of the ciliated infusoria. He also noticed the constant occurrence of *Monads* belonging to the species *Circomonas fusiformis*, or *acuminata* of Dujardin, etc., in pure distilled water after a certain exposure to the air, and this without the previous admixture of vegetable matter of any kind in the water. The same results were obtained upon shaking rags, from various and distant parts of the world, over the distilled water; other experiments were also tried, and in all cases in

about three weeks he invariably obtained forms of ciliated infusoria. "The fusiform body of the *circo-monas* bears a long whip-like cilium at its anterior end, and a short seta at its caudal extremity: this finally drops off, and when exposed to undue heat and light, the animal is transformed into an *Amœba*."

Mr. Samuelson's results do not very materially differ from my own, save in one or two particulars. I have not seen the succession of generations take quite the same course, and the animal and vegetable bodies generally appear simultaneously, or so soon after each other, that it is at times difficult to decide the priority of appearance; but as my experiments have been chiefly confined to collections of rain and distilled water, *without* the addition of vegetable matter of any kind, this will materially affect the results. We are, however, quite agreed as to the wide and general distribution and great tenacity of life presented by these infusorial germs. With regard to the supposed purity of rain-water, at no time can it be taken without the numerous matters floating in the air being brought down with it, and, consequently, within a few hours after it is caught, *Protococus pluvialis*, *Amœbæ*, and *Circomonas*, may always be found in great numbers. It is somewhat remarkable that the purest snow water, caught in a clear glass vessel, and allowed to remain well corked, will, in the course of two or three weeks, be found to contain *Amœbæ* and *Circomonas*, but it rarely presents other forms of animal life; the vegetable matter completes its growth very slowly, gradually passes to confervæ, and for a time no other change is seen to take place; so that it is painfully apparent that the atmosphere in which we live and move and have our being is something more than a mixture of gases, as apparently determined by chemical analysis.

Mr. Glashier's "*blue mist*," which he believes to be in some way associated with our cholera visitations, certainly does not depend upon the presence of any unusually large number of spores floating about in the air. Although spores, etc., exist, as I have shown, in the atmosphere, in greater abundance about the period of such visitations, they also exist when the public health is good. And therefore it should be regarded as a mere coincidence, if certain bodies prove to be more abundant during the prevalence of epidemic disease. But this "fungus-spore" theory is no new thing, for it is upon record that rusts and mildews have sprung up so rapidly upon articles of food and clothing, as to have appeared to herald approaching plagues. A so called "blood-rain" is said to have been the forerunner of the plague of Rome. It has been noticed, however, that the present year (1866) has been especially characterized by the prevalence of all kinds of moulds and mildews upon vegetation generally; we consequently

find the air thoroughly charged with the germs of *Uredo* (smut) and *Penicillium;* and we may readily believe that the same depressing influences that render the human family subject to epidemic disease also affect vegetable life, and the weakly and sickly plant equally with the higher human creature, goes to the wall, and may ultimately furnish the nidus for a colony of parasites.

In all my collections of rain, snow, and distilled water, animal and vegetable life proceeds to one definite point, and then recedes. I have never found any go beyond *Euglena;* and unless some vegetable matter be added to the solution, no higher form of life appears; on the contrary, a retrogade condition takes place. If some kind of vegetable matter, as hay or lettuce-leaf, be added, then I find, with Mr. Samuelson, rotifers make their appearance—not otherwise. But here, again, we get no further, and the infusion requires a something more to give it a start in life. As might be predicted, these changes are all modified, accelerated, or retarded by the action of light, heat, season, and so forth, and by the presence of any albuminoid material. If fresh-caught rain water be filtered and excluded from atmospheric influences, the appearance of both vegetable and animal life is very much delayed; but when fresh and clean rain water is exposed to the air, *Protococcus* quickly makes its appearance, and with it *Amœba;* the cells of the *Protococcus* soon throw off zoospores, and the *Amœba* take possession of the cells and feed upon the zoospores. I mention this latter circumstance, because some observers, both before and since Cienkowski, having doubtless seen the same occurrences, have stated their belief in the conversion of the contents of the cells of the *Protococcus* or *Chlamydococcus* into a free moving mass of amœboid bodies.

Mr. Carter, well known for his valuable contributions to microscopical science, was one of the first to notice and promulgate this apparently impossible transitory condition of the volvox-zoospores; but he afterwards saw fit to change his opinion, and in place of looking upon it as the conversion of the vegetable protoplasm into that of an animal, he now believes that the germ of the *Amœba* must have been included in the vegetable cell, or as a parasite made its way into its interior; and remarking upon his first statement, that *Acitenæ* are thrown off by *Vorticellæ*, he writes thus: "Seeing, then, the great analogy, if not real identity, that exists between the nature of these organisms, I would suggest that the germ of the *Acitenæ*, like the egg of the *Ichneumonidæ*, becomes encysted in the *Vorticellæ*, and lives upon its host." *

* Carter. *Note on Organization of Infusoria.* Ann. Mag. Nat. Hist. Series 3. Vol. viii., p. 207.

To my mind this view scarcely admits of a doubt, and it is clear that the young of the *Amœba* in some manner find their way into the cell, just as it is on the point of breaking up, and so become developed in a situation where they are at once provided with a due amount of nourishment for the support of their earliest state of existence. I must not, however, omit to say that no less an authority than Dr. Hicks still holds to the former opinion, and fully believes, after many careful observations, that these bodies, which move freely about in the cell, ever changing their position, protruding and retracting portions of their membranous walls, exactly as the *Amœba* do, are really and positively what they appear to be, animals belonging to the class of *Rhizopoda*. He further observes, that after the amœboid bodies have begun to shift about in the cell, for every such moving body there was a corresponding empty space; and he cannot suppose it possible that any parasite could enter the cell from without, but that every examination tends to confirm his opinion that the amœboid organism is really the product of the metamorphosis of a mass of vegetable protoplasm.

Another careful observer, Mr. Archer, of Dublin, has also recorded the development of amœboid bodies in the cells of *Stephanosphæra pluvialis;* he looks upon the phenomenon as analogous to that which is known as occurring in one of the stages of development of the *Gregarinida*, the encysting stage; the central nucleus and vesicle disappear, and after a certain time "the mass breaks up into a series of rounded portions, which become elongated and slightly pointed at each end, constituting a little body which has been called a 'pseudo-navicella,' from its striking resemblance to the Diatomaceous navicula; the capsule next bursts, and the pseudo-navicellæ are scattered, and pass out of the body of the creature which they inhabited." *

Dr. Hicks believes that he has seen the young volvox pass into an amœboid state; in other words, the conversion of the protoplasm of a vegetable cell into an animal. He says, "Towards the end of the autumn the endochrome mass of the volvox increases to nearly double its ordinary size, but instead of undergoing the usual subdivision, so as to produce a *macrogonidium*, it loses its colour and regularity of form, and becomes an irregular mass of colourless protoplasm, containing a number of brownish granules."†

* Huxley.

† I have continuously had the volvox under the microscope during the past summer and autumn, and made more than a hundred examinations without having once seen anything approaching to the form of an *Amœba* in the interior of the cell.

The final change and ultimate destination of these curious amœboid bodies have not yet been made out; but from Dr. Hicks's previous observations, made on similar bodies developed from the protoplasmic contents of the cells of the roots of mosses, "which in the course of two hours become changed into ciliated bodies," he thinks it very probable that this is designedly the way in which these fragile structures are enabled to retain life, and to resist all the varied external conditions, such as damp, dryness, and rapid alternations of heat and cold. "The philosophic mind," observes Mr. Carter, "takes up this line of argument." No one can at first sight witness the changes which take place, almost like a dissolving view, in the protoplasm and chlorophyll of *Chlamydococcus*, *Eudorina*, and in that of the cells of the *Algæ* generally, and during which they pass from their original form into that of a rhizopod, without inferring that the form produced is merely another one of that which preceded it, and not an absolute change. Hence my description of the fancied passage of the vegetable protoplasm into *Actinophrys*." *

Passing on to the consideration of another stage of this inquiry, we must be struck with "the remarkable powers of multiplication by fission and gemmation which many of the group exhibit; within the last few years the investigations of Müller, Balbiani, Stein, and others have shown that these minute creatures possess a true process of sexual reproduction, and that the sexual organs are those which have been hitherto denominated the 'nucleus' and 'nucleolus.'"† And ultimately it will be found that the infusoria have a life history as important as that of the higher classes of animals. Dr. Grant in 1851 recorded the presence of ova in one of the marine sponges (*Tethya*), thus showing that the Protozoa formed no exception to the other sub-kingdoms of animals in the possession of these essential elements. Five years later his observations were corroborated by Lieberkuhn, in the case of one of the fresh-water sponges. Even then the existence of the generative elements still remained to be demonstrated in the Infusoria. Ehrenberg, it is true, had drawn particular attention to the "nucleus," and some others took note of certain minute filaments, but there these observations rested. Now, however, the whole aspect of this subject is changed, and for the vagueness which, four or five years ago, charac-

* The circumstances under which the moss-roots should be placed to show these phenomena, are to float any common moss on a glass of water in the shade; and when the radicles thrown out are of a considerable length, they may be removed to the slide and examined. Care must be taken not to expose them to too much light and heat."—Dr. Hicks's *Quarterly Journal of Microscopical Science*, 1862, p. 103.

† Huxley.

terized all attempts to explain anything like a generative function in the Infusoria, we have substituted, by Balbiani, a clear and complete survey of their leading phenomena. The Infusoria have long been known to multiply by spontaneous fissure, gemmation, and the production internally of various formed bodies, which many observers have described under the name of "embryos." The phenomena of "encysting," "conjugation," etc., which these minute bodies frequently exhibit, and the relation, real or supposed, between such processes, and their various modes of propagation, have from time to time afforded matter for no little controversy. M. Balbiani's investigations, however, derive additional interest from the very complete manner in which they have been carried out. As an instance of this, he states that in his examination of *Paramœcium aureliæ* he could not look upon them as conclusive until he had succeeded in extracting uninjured some of the eggs from the parent body, and had subjected them to the action of the surrounding water; when he saw each egg resolve itself into two portions, the smaller being enclosed within the larger, then by employing reagents, acetic acid and iodine, he produced the changes more rapidly; and in this way again and again obtained abundant proofs of the truth of each observation. So much then for Dr. Balbiani's researches on the phenomena of reproduction among the Infusoria, which have added most valuable information to our former meagre knowledge of these interesting forms of organic life.

The case of the Infusoria is, in some respects, comparable to the fertilization of Orchids, which Darwin has investigated with so much care, and rendered doubly interesting by showing how highly complicated are the contrivances by which among this beautiful and extensive group of hermaphrodite plants, fertilization is accomplished, and that, save in a few exceptional instances, self-fertilization is almost impossible. Comparing the Infusoria with Orchids, we may see that their fecundation is effected by constant dissimilar elements produced in different individuals; and in both cases the details of the process are curiously varied in their several tribes.

In 1819 Chamisso detected the mode of reproduction of the *Biphoræ*, and coined the term, "Alternation of Generations."* He found that the isolated *Salpæ* only produced chained-salpæ, and then only by gemmation; whilst the chained-salpæ produced isolated ones, and only by ova. The discovery of the now well-known life history of the *Medusæ* was next made by Saars and Siebold; it was shown that the *Medusa aurita* deposits an egg, which gives rise to a polyp,

* This term is more generally associated with the name of Steenstrup, the well-known author of a learned and valuable treatise on the subject.

which grows by gemmation and fissuration, and produces from a single individual several small medusæ, which again in their turn produce ova. Other phenomena were soon collated with these, as the fissiparous generation of Annelidæ, the various processes exhibited by certain Spongidæ and Infusoria. In 1845, T. Müller described the remarkable larvæ of the *Echinodermata*, from whose viscera the future perfect being is thrown off by a process of gemmation; and the researches of Kuchenmeister and Van Beneden afterwards fully illustrated the remarkable migrations and metamorphoses of the Helminthoid worms. "In the *Distoma* the embryos have at first the form of ciliated monads, these are metamorphosed into Gregarina-form worms, and in the interior of each of the latter, numbers of *Cercariform*, or tailed animalcules, are developed, which ultimately become true Distomata."

Quatrefages and Professor Goodsir, however, look upon all this as simply a part of the process of growth, comparable to the growth of a lost or mutilated limb in the Crustaceæ. The gemmation of the Hydra, the medusification of the Polyp, the peculiar virgin-propagation of the Aphis, the segmentation of the Nais, the gradual development of the Echinoderm within its Phitean larva, and all similar instances, are regarded as mere phenomena of *growth*, and not as illustrations of the *Parthenogenesis* of Owen. And this view is now held by nearly all biologists. We might even go a step further and point out that recent investigations have established the wide spread existence of *polymorphism*. One of the fungi has been known to possess six different kinds of fructification; the *Uredo* exhibits four, and others might be named, which were formerly looked on as distinct species.

In some of the gemmiparous animals new creatures are at times multiplied to an almost incredible extent by simple mechanical division. I have seen, after breaking away an Actinia from the side of my aquarium, a number of small pieces of the foot-stalk left adherent to the sides of the vessel; all of which fragments became in a few days perfectly-formed young Actiniæ. The *Hydra viridis* may, as we know, be divided longitudinally, or transversely, into several parts, and each part will become a perfect polyp; or if a wound be made in the body of the animal, a new one sprouts from the site of the injury.

"The gemmiparous form of generation is met with in a large variety of animals. It exists in the Infusoria, Entozoa, Polypi, Medusæ, Annulata and Tunicata. In the *Nereis* a constriction first appears in the tail of the animal, immediately behind which the head of a new *Nereis* is developed, and the posterior division becomes separated from the anterior, or parent, as a

perfect animal. In this form of reproduction animals are formed, not from ova, or from the fission of primary reproductive cells, but from secondary or derivative germ-cells, placed in reserve in the tissues of these animals. The same process occurs in the *Triton* or the lobster, when a broken-off claw or tail is replaced, the new formation springs from derivative germ-cells placed in the claw or tail—that is, a reserve of derivative germ-cells, not wanted for use in the general development, is deposited in these different parts of the body."*

Professor Goodsir believes that "the regenerative faculty does not reside at any part of the claw of the lobster indifferently, but in a special locality at the basal end of the first joint. This joint is almost filled by a mass of nucleated cells surrounded by a fibrous and muscular band."

With respect to the Hydra, its reproduction is indifferently by gemmation or by true ova. The young hydra from the egg is identical in structure and character with that produced by budding. Nearly all writers now regard gemmation and generation by ova as two essentially distinct processes; nevertheless, the identity of the results is clearly seen in Mr. R. Crouch's observations on the Sertularian Polyps. "At certain seasons of the year," he says, "they produce cells much larger than those of a more permanent character. These are at first composed of the granular pulp of the stem, afterwards the pulp becomes furrowed, and finally formed into cells. After a short period they separate from the parent, and undergo the process of development. If these cells attain a certain size they are developed into eggs: if, on the other hand, they are stunted by cold, or otherwise interfered with, they are formed into polyps, while, if from further unfavourable circumstances they are rendered still smaller, they grow into branches, and thus we see that, according to circumstances, different organs are capable of being eliminated from the same structure."

It appears, then, that there are three forms of reproduction, fission, gemmation, and generation by ova; in other words, "*Fissiparous*, when a cell spontaneously divides into two or more: *Gemmiparous*, when a plant or animal sends forth young branches from its stem; *Oviparous*, when the young are produced from seeds or eggs." If we endeavour to arrange the known facts of reproduction, proceeding from the simple to the more complex, we must begin with a very simple process; namely, that of a single cell spontaneously multiplying itself by subdivision. In all the albuminous, starchy, or gelatinous matter called *protoplasm*,† a single cell appears, it assimilates

* Huxley's *Lectures on Comparative Anatomy.*

† *Protos* (πρῶτος) first, *plasma* (πλάσμα) formative substance.

more and more of the fluid portions of the protoplasm, and then divides into two parts, perfectly symmetrical; these two quickly divide into four, eight, or sixteen, and so go on multiplying until a number of cells is produced, each cell being attached to its fellow by its wall, but capable of a separate existence. By this process of subdivision, a single cell of *Protococcus nivalis* (Red snow plant) has been known to redden in a single night vast tracts of snow, and the *Bovista giganteum* is estimated to produce in one hour no less than four thousand millions of cells. Ehrenberg computed the increase of the infusorial animalcule, *Paramœcium*, at two hundred and sixty-eight millions in a month. This simple mode of reproduction is certainly identical with that of growth of both plants and animals of a higher type.

If we ascend a step we reach the second form of reproduction, namely, the union of two *similar* cells, termed by botanists "*conjugation.*" This consists in the coalescence of two similar cells to form a new starting point from which multiplication may proceed. Instead of two cells in the same filament we may have two cells in contiguous filaments coalescing, but in each case it is the union of two similar cells. From the fission of one cell into two, and the conjugation of two similar cells, we pass to the third mode of reproduction, namely, *generation by ova*, or the union of two dissimilar cells, and for the production of the more complex organisms, the union of germ with sperm-cells is indispensable.

By these several separate modes of reproduction we must admit that there is nothing more marvellous in an animalcule producing several millions of its kind, than in a plant constructed by as many cells, each produced by a process identical in every way. In the development of the tissues of the animal body, the newly-formed cells increase by division: and become determined in their growth by the character of the secretion elaborated within the walls of those previously existing. The formation of the more complex animal tissues takes place in the same way as that already noticed in plants, with this difference, that the mother cell contains a nucleus, within which is seen a very minute body called a nucleolus. The nucleus has the power of appropriating, or drawing in, a certain portion of the surrounding material—protoplasm—enlarges, and ultimately divides into two perfect cells. From the aggregation of such cells we have the animal body built up in all its complexity.

We have thus far traced the development of organic life through some very curious and highly interesting stages, and we have seen that life, in all cases, whether in the highest or lowest forms, depends upon perfection of organization for

development and maintenance; but it must not therefore, as we said before, be supposed that it is altogether the result of organization, for death may occur without any trace of organic lesion to account for it. Nevertheless, the extent of organization necessary to the enjoyment of life is apparently very small indeed. A simple cell constitutes the entire organism of such plants as the *Chlamydococcus* or the *Palmella cruenta*, or even an animal, as the *Amœba*, and in these and such like simple structures resides a vital principle on which its integrity depends. But whatever the *extent* of organization may be, its perfection is essential and necessary to the maintenance of life; for, as we now know, the seed which has been dormant a thousand years will, if its organization be perfect, spring into activity when planted; but if crushed, its living principle is destroyed, and it will no longer germinate. Thus it is exemplified that to those minds familiarized with the phenomena of life, as manifested by the simpler organisms, the microscope "is not the mere extension of a faculty, it is a new sense."

THE NOVEMBER METEORS.

BY HENRY J. SLACK, F.G.S.,

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On the night of the 12—13th November the anticipated meteors were magnificently seen from my house in Camden Square, N.W. Occasionally mist and cloud drifted across the clear sky, but no large portion was obscured at any time between 11 p.m. and 3½ a.m., and when the interrupting vapours came, they were generally thin enough to allow the stars to peer through. At just about 11h. 8m. p.m. a magnificent fire-ball as bright as Jupiter passed over Betelguese and under Bellatrix in a nearly horizontal path. It had a beautiful greenish train, with undulating smoke-like edges. At (about) 11.37 a reddish meteor shot upwards under Mars, with a train lasting half a second. At (about) 11.41 another meteor shooting upwards, vanished near Castor; and at (about) 11.48 a very fine one appeared under Rigel, slightly sloping to the south, and displaying a yellow and green train; the train of this meteor was of a character frequently seen later in the night. The margins were like fine gold dust, and the centre a singularly beautiful pale emerald green. The golden yellow might be called between three and four of Admiral Smyth's scale, and the green though more emerald in hue, between the same numbers of his greens.

At (about) 11.51 two meteors shot from under Pollux and vanished beyond Orion; these had yellowish red trains. At (about) 11.54 the train of one west of Capella lasted from two to three seconds, and three minutes later the train of another exhibited the aspect of a narrow shower of closely packed sparks. At (about) 12.8 a meteor with a similar train, but red, appeared below Capella. At (about) 12.13 one shot up from below Mars towards Betelguese: the ball was orange and the train bluish green. At 12.13 I looked at a meteor moving towards Castor, through a Herschel-Browning spectroscope, and it exhibited all the colours; its train lasted about three seconds. About 12 p.m. my wife joined me, and while I looked from Leo to Orion, she watched a sky space from Orion to the S. W. Towards one o'clock the meteors came thicker and thicker, and from 1 to 1.30 it is scarcely an exaggeration to say that all the heavens were a blaze with fiery balls and long streaming tails of coloured light. The long trains stretched from 40, 50, to 60, 90°, and possibly greater lengths. In these cases a large proportion of the whole length of the trains was in a highly lustrous condition at the same moment of view. The effect was that of a continuous stream of burning particles left behind by the meteors in their course, and quite different from any luminous appearance that might arise from mere compression of the air in the fire-ball's flight.

Looking towards Leo it seemed as if a celestial rocket battery had been established in that constellation. A few meteors went downwards from γ Leonis, and many more upwards from the same star; but the majority had a more central radiant point. Upwards they shot by dozens, scores, and hundreds; now pelting past Procyon and through Orion, now bombarding Castor, then up to the zenith and down again: then through the Great Bear, under and over the pointers. Occasionally a little to the south of γ Leonis, meteors burst, and disappeared immediately, showing no trains. Probably their tails were behind them, and invisible from the foreshortening of perspective. At the same time the meteoric shower went on in descending curves west of the zenith point, and by 2.15 we had counted 1,400, excluding at least a hundred more seen before they came thick and strong, and our attempts to number them began.

At 1.22 my wife saw one perform a zigzag below Orion. The ups and downs of the W it made, were shorter than is usual with forked lightning.

In addition to the long tailed meteors, we saw many with short fan tails. None of these reached any great height above the horizon, perhaps not more than 45°, and their tails exhibited glowing rainbow tints. These came from Leo. My wife saw some with light blue trains, and some with purple.

Catching meteors in a spectroscope is not an easy task. It is a sort of celestial snap-shooting in which there are more misses than hits. From the luminous glow which filled the whole atmosphere, and which was heightened by the London gas-lights, it was hopeless to spectroscopize trains, except at their brightest. Out of a dozen or two I saw through the instrument, the best defined spectra were yellow and green from the trains, and with all the colours when the nucleus or ball was in the field. My wife compared one she saw of a ball, to the spectrum of Sirius, but brighter.

I tried, ineffectually, to catch some of these shooting stars in my six and a half inch telescope, but they evaded me. I put on a large, low, eye-piece—an aplanatic of Horne and Thornthwaite, —which, with my instrument, gives a field of 4m. 15s, and pointed it at stars near which meteors were flashing, but although fresh supplies came in the expected direction, they provokingly went a little too high or too low.

The great majority of the meteors were as bright as first magnitude stars, such as Vega and Sirius; some as bright as Jupiter; others rivalled Venus, but few, if any, exceeded her. One of the largest I saw shot horizontally in the N. E, and burst with a irregular flame at (about) 2.38. A shower of sparks came from one near γ Leonis.

At the height of the shower the meteors came in batches and volleys. Sometimes two or more travelled close together, and at others, sets of four or five flashed in diverging courses from various parts of the heavens.

Near two o'clock I marked the paths of a good many on one of Herschel's British Association maps. Most of them seemed to converge to a point between α and ι Leonis, but the courses of several that passed through Gemini and Canis minor would, if continued straight backwards through their points of first visibility, have converged in Leo minor. The radiant point of the great majority was undoubtedly in Leo, and we must wait for Mr. Herschel to compare the various observations, and give us an accurate estimation.

The duration of the trains is probably underrated from their tendency to be lost prematurely in the general luminosity of the sky. Mr. J. Symons saw some for two minutes through a two and a half inch telescope. We saw several flashes like lightning, but whether they were really electrical discharges, or the light of meteors bursting out of sight, I cannot tell.

From the impossibility of two persons seeing and counting all the meteors, the total number must be set down as considerably in excess of our enumeration. We counted 1500 by about 3 a.m., and adding 100 or so seen earlier, this makes 1600—a portion only of the entire display. If these bodies are

regarded as microscopic planetoids, one night has consumed —burnt up—many thousand little worlds, and their remains are diffused in our atmosphere, or scattered unnoticeably on our earth. To meet and burn up a shower of these little bodies and convert them into most glorious fireworks is a pleasant incident in the journey of our earth-ball through celestial space, and perhaps the most enthusiastic advocate of the habitability of the planetary worlds does not consider that we have brought to a fiery ending the lives of microscopic populations on these tiny globes.

These shooting-stars, periodically met with in swarms, appear to be circling round the sun like larger planets, and it happens at recurring intervals that their orbit crosses ours when we are near enough to attract them into our atmosphere, which they enter with velocities of thirty or forty miles a second, and get burnt up through the heat which the friction engenders. A cannon-ball moves at about 1600 feet per second at its greatest velocity, and when we consider how insignificant this motion is when compared with thirty miles a second, we may imagine the intensity of the heat developed by friction even against the particles of highly attenuated air.

From the small size of the bodies of the shooting-stars their bombardment of our earth is unable to do any harm or produce any visible effect on its surface, but if there be swarms of bodies as big as the great meteoric stones, and likely to get in our way, future astronomers may not find watching a meteor shower so agreeable an affair as those of this generation found their labours on the famous November night in 1866.

We may add an interesting observation of the Rev. E. L. Berthon of Romsey, who says—"One most brilliant, rose coloured globe, which passed through Gemini below Pollux, left a long train of blue light, which continued like a comet 16° long for three minutes, and then gathering itself gradually into a wisp, remained in sight for six minutes and twenty seconds." Between one and two o'clock Mr. B. Scott, F.R.A.S., saw from Weybridge two meteors in the west, which he describes in the *Morning Star* as "revolving, like partners hand in hand in a country dance, round each other, describing spirals of light."

Papers already published in the INTELLECTUAL OBSERVER will supply much information for which we have been asked, and we shall resume the subject in our next number, supplying full answers to inquiries for popular expositions. A general account of *Falling Stars and Meteorites*, by Professor Ansted, will be found in vol. iv., p. 157. In vol. i., p. 217, is a paper by Mr. A. S. Herschel, on the *Observed Heights of Meteors*, illustrated by a diagram. In vol. iii., p. 31, is a translation from M. Quetelet's *Physique du Globe*, containing much valuable information on shooting stars, with a diagram, showing the

frequency of these meteors in different months. The meteor of Nov. 22, 1862 (with a sketch) is described by Mr. E. J. Lowe, vol. ii., p. 422. *Remarkable Detonating Meteors* of Feb. and Nov., 1865, are described by Mr. Herschel, vol. ix., p. 99. The "Herschel-Browning Spectroscope," is figured in the article called *The Coming Meteoric Shower—Spectra of Meteors*, Aug. number (1866), p. 38. In the last paragraph but one of this article, read *gaseous* matter instead of "porous." This paper contains important extracts from Mr. Herschel's lecture at the Royal Institution. The October number (1866) commences with a most important paper by Mr. Herschel on the *Prismatic Spectra of the August Meteors*, illustrated by a coloured plate.

FATIO ON THE FORMS AND COLOURS OF PLUMAGE.

M. Victor Fatio has kindly sent us a copy of his important paper on "*the Different Modifications in the Form and Colouration of Plumage*,"* of which we shall proceed to give an account, with extracts from the more important passages.

Speaking of the down first developed in birds, M. Fatio says, "In the thickness of the skin, on a growing bulb, and in the place of the future feather, the down grows and developes itself in a manner analogous to that which we shall presently study in the feather. It moves on little by little as it grows through the cutaneous layers, and at last pierces the surface in the form of a hairy looking material, ordinarily composed of eight to twelve, and sometimes of as many as twenty-four distinct filaments. This down does not always possess a stem and central axis like the barbs of a feather, and resembles those barbs which are held together by the extremity of a small special sheath. Down not only belongs to a young age, for we find it as a protecting covering of adult birds, whether garnishing the base of the stems of nearly all feathers, as a material without axis, at the base, and in the middle of the principal stem, or lastly when arranged on a separate stem, isolated and developed in the single tube of the principal feather, and lining to a greater or less extent its internal surface. This arrangement constitutes the double feathers of our Gallinaceous birds, and of our birds of prey, and is seen in the triple feather of the cassowary of the Indian Archipelago."

M. Fatio enumerates three sorts of down—cutaneous down, basilar, and feather down. The first is directly attached to the skin, the second confined to the basal portion of the feathers, and the third to the principal stem at the sides of downy feathers. The barbs in these downs vary a little in form, but

* *Des Diverses Modifications dans les Formes et la Colouration des Plumes*, par Victor Fatio. (Tiré du Memoires de la Societé de Physique a d'Histoire Naturelle de Geneve, tome xviii, 2me. partie.)

still more so the barbules in different groups of birds, or in different positions of growth. Down is often coloured: sometimes by the irregular diffusion of an internal pigment, in its barbs and barbules, and sometimes by pigment deposits in regular order and definite positions, and in parts swollen out, like the antennæ of certain insects.

"After a greater or less lapse of time the feather, which has followed the path prepared for it by the cutaneous down, drives before it the latter and its sheath, and at last thrusts out its downy termination. The great quill feathers, whether wing or tail, generally appear first, and a feather generally consists of a *stem*, or central axis; *barbs*, or secondary axes, lateral or branching from the former; *barbules*, tertiary axes implanted in the barbs, or between them on the stem; *hooklets* (*crochets*), appendages of the barbules, or quaternary axes." These parts exhibit an *epidermis*, formed of flat, irregular cells, and below this a larger *cortical substance*, formed of elongated cells, or their fibres; and in the centre a *medullary axis*, continuous or segmented, formed of regular pigment cells, polygonal or rounded. Besides down and feathers, most birds have, on the nostrils or feet, piliform feathers, which, as their name intimates, resemble the hair of animals. They are stems without barbs. Some birds, like the wax-wing (*Bombycilla garrula*), have horny and coloured developments at the end of some of their feathers, which, as we shall show, are probably barbs conglomerated together. Other species have defensive spines composed by the union of several feathers, united by extravasated pigmentary matter, and strongly reminding us of the formation of rhinoceros horn, by the coalescence of hair.

In studying feathers, M. Fatio says we must distinguish in the hooklets between those which have true quaternary axes and those which are merely outlying portions of the cortical matter. The first feather of a young bird is not always constructed exactly like that which succeeds it. Its barbs are lower and more distant, and its barbules have fewer hooklets.

In a young bird still in its shell, Engel has shown the existence of definite spots and rows of mother cells from which the feathers arise. "The primary cell divides into smaller cells, some of which accumulate in a basilar bulb, and then range themselves round the circumference, and others occupy the centre. The sheath which envelopes these primary materials, has at its base an orifice, commonly called the *inferior umbilicus*, and through it pass blood vessels, which convey to all parts the elements necessary for their progressive development. The plastic pigment-bearing matter forms gradually, and the cells which it produces, and as they take up their places they elongate

the rudimentary feather, which, furnished with its envelope, advances obliquely under the epidermis. The constituent pigmented cellules, polygonal, round, and nucleated, arrange themselves in series, composing the barbs, barbules, and axis of the feather."

"As the cellules which constitute the cortical portion develope and group themselves, their nuclei disappear in part, and they elongate themselves and assume a fibrillose form."

When the end of the growing feather has become firm enough to pierce its sheath, it puts forth the terminal barbules of the perfect feather, at first rolled round their axis, but soon developing into a tuft by the elasticity they acquire in drying. "They are coloured as the extremity of the adult feather should be, and have received already all the pigment which they will obtain." As the growth proceeds, each part receives on emerging from the sheath all the elements of colour which it will afterwards exhibit. At a later period the blood vessels are obliterated, the inferior umbilicus closed, and the sheath thrown off, and the pulp which constitutes the life of the feather dries up.

In a chapter on "true moults," M. Fatio explains that each bird, whatever its species, receives in its first feathers a certain dose of pigment, and after its first moult the new feathers are supplied with a fresh dose of new pigment, which, being differently elaborated, causes the bird to assume a different livery. M. Fatio regards the autumn moult as the true and most complete one, while the spring moult is more or less complete as the existing feathers are capable or incapable of modification. The special decorations which appear on the head and neck at the love season arise from local irritation. When a feather has gone through its course of growth and modification, it gradually dies, and is usually thrust out by a new feather growing at its base. M. Fatio cites on the authority of M. Lunel, the case of a goldfinch which had two complete sets of wing feathers, resembling a double set of teeth; the new ones having emerged a little out of their true direction, and not having thrust the others out.

"We have seen," says M. Fatio, "that when a feather has reached its natural size, and has thrown off its external sheath, the internal marrow dries up, and an operculum closes the inferior umbilicus. This drying up and closing are most complete in the longest feathers, but in no case is there any further supply of blood. The researches which I have been able to make on this subject, in many birds, as well as the observations of many authors, like those of M. Martin at the *Anas nigra*, demonstrate that the skin at the base of a dried feather does not exhibit the local inflammation or sanguine turgescence

noticeable at the base of a growing feather. A feather once dried, receives no more blood or pigment, because it no longer grows from its base."

Besides variations of colour produced by moults, other colour changes occur in most birds, taking place gradually from the end of the autumn, and in some cases going on rapidly at the approach of spring. Two principal phenomena are exhibited in these colour changes: "the interior pigment dissolves and spreads, while the extreme parts of each feather fall and allow the new colouration to appear, which has been formed below them, and thus showing suddenly a new livery which had been concealed."

M. Fatio describes the latent colour as residing in pigmentary granules, not dissolved, isolated, or grouped, and usually confined to the centres of the different parts of the feather to which they are to impart a new colouration. The colour which is seen is spread through the cortical substance of the same parts, and arises from an anterior colouration of other pigment granules, or of a subsequent solution of latent pigment deposits. Light, atmospheric moisture, and temperature are agents influencing these changes, operating in conjunction with food and the sanitary conditions of the bird.

"Here," exclaims M. Fatio, "are two feathers from the same part of the same bird—one an autumn feather, uniform, or variegated, with clear tints, dark, but comparatively feeble and not lustrous; the other, a spring feather with more definite and brilliant colouring. I place the autumn feather under the miscroscope, and, studying it with magnifications of from 80 to 300, I notice in its tissues the two conditions just spoken of; the colouration more or less strong, transparent, and diffused: and also its internal deposits somewhat diminished, or disappeared, from the extreme parts, such as those of the barbs and barbules. The pigment in the axis has been dissolved in, and spread abundantly through, the surrounding cortical substance; some parts being largely developed in their proportions."

After citing the opinions of other observers, M. Fatio describes his own experiments, and states that by exposing the feathers of the starling and linnet to the influence of moisture by immersing some in water, and floating others on the surface, they soon exhibited a sensible development of their cortical substance in the barbules of the starling, and in the barbs of the linnet. At the end of twenty days the pigment was not dissolved, or only so imperceptibly.

In another experiment M. Fatio moistened feathers with water, and gradually heated them on a plate of glass. He noticed at first a slight extension of colour in the tissues, and

when the moisture was evaporated, a perfect sketch of the barbs and barbules was traced upon the glass by a deposit of greasy matter.

In another case he wetted the feather with alcohol, but still obtained the sketch in greasy matter, which he considered to demonstrate that besides the coloured pigment, most of the tissues contained a little colourless grease.

Having satisfied himself that this diffused and colourless grease did not act as a solvent of the pigment granules, to which he ascribed a greasy nature, he made further observations thus described:—"I set to work to study and compare under the microscope the basilar tubes (quills) of different feathers in process of colouration, and I noticed always many greasy colourless cellules in the tissue of the tube, in its inside, and in the cortical substance of the parts nearest the stem, close to the spot where many of the feathers exhibited a marked strangulation. I could not, however, make out the channels this grease must follow, and I endeavoured to dissolve it on the field of the microscope. Having introduced a drop of ether between the two glasses that enclosed the feather, I saw like a circular canal, opening at the base of the stem, and probably able to conduct the grease between the remains of the subcutaneous sheath and the external wall of the tube; and I noticed within, a possible direct communication, between the hollow of the tube and the broad layer of cortical substance which looked like a channel of porosity. I speak now of small feathers, in which a less complete internal desiccation may more easily allow this internal circulation of greasy matter than the large feathers, in which the cortical substance becomes more opaque and horny with lapse of time."

To test these suppositions, M. Fatio dipped the quill ends of two small feathers in solution of carmine, having left one intact, and stripped the barbs off half the stem of the latter. At the end of twenty-four hours he found the carmine had ascended either externally between the sheath and the quill, or internally through the diaphragms formed by the cortical substance. In the first feather the fluid had ascended comparatively little, because it was carried off laterally by the barbs; but in the second it rose up to the point at which the barbs were left.

M. Fatio in further pursuit of his analysis, "procured a linnet whose breast feathers already showed a little of their spring colours, and having delicately applied to them the grease contained in the bird's oil-glands, soon perceived a more intense colouration, which was increased by heat. This colouration was not fugitive like that which grease or water will

produce on any feather, but remained intense and brilliant after many washings with alcohol and complete drying." The same experiment succeeded with the feathers of a finch (*Fringilla cœlebs*) and similar results were obtained in a few minutes by the use of olive oil.

With reference to the large feathers, M. Fatio remarks that birds in preening their feathers pass their beaks all along each wing and tail feather, regularly taking a supply of grease from the oil-gland. He adds, "if a change of colour does not begin regularly at the extremity of a wing feather, as is usual with the smaller feathers, it is because it is much more exposed to the action of the air than the latter. And if sometimes the colouration does not proceed regularly in a small feather from the periphery towards the centre, it is for the accidental reason that some parts have been more exposed to moisture and light, or more readily penetrated by the grease." He further observes that the oil-gland becomes larger at the approach of the love season, and that fat birds usually exhibit the most intense colours.

"The external grease is absorbed by the barbs and barbules, and penetrating by endosmose or capillarity the more or less porous tissues fills the empty spaces, and finding its passage facilitated by dilatations occasioned by moisture, it gradually dissolves the fatty pigments they contain."

"Thus under the influence of moisture, alternately absorbed and evaporated, as a preparatory developing agent, afterwards of the grease of the body as a solvent, then of temperature and light facilitating chemical action, the feather colours itself, and changes and augments its tints."

Referring to the labours of other observers, M. Fatio employs the divisions of Bogdanow, but adds to his "ordinary feathers" others which he calls mixed, and to his "optical feathers" others which he calls enamelled (*emaillées*). "Ordinary feathers," although often brilliant, do not exhibit metallic reflexions, and they show by their transparency an internal pigment resembling the colour they exhibit by incident light. The "optical feathers" exhibit reflexions, and show by their transparency an internal pigment of a different shade to the colour they assume in incident light. The linnet furnishes "ordinary," and the starling "optical feathers." "From their first appearance out of their sheaths, I see," says M. Fatio, "essential differences between the ordinary and the optical feathers which grow after the autumn moult on the breast of these two birds. I perceive, it is true, on all those parts which are about to fall, that they are grey or brownish in the linnet, or white or yellowish in the starling, but I notice in the former, barbules slender and slightly coloured, while in the latter the

extreme barbules are already large, well coloured, and even showing metallic reflexions. As these feathers finish their growth, as well as after their complete moult, they show the same difference—an inferiority of development and colour in the barbule of the ordinary feather as compared with an optical one. If I look at the feathers of the same birds in spring, I am struck by a series of differences which multiply more and more between the ordinary and the optical feathers, as I enter more minutely into their details of development, structure, and colouration. In the first place to the naked eye merely, the linnet's feather is shortened through the loss of its brown extremities, and has become red by a more complete solution of its internal pigment, whilst the starling's feather which has lost its white tip, and the ends of its upper lateral barbs has taken a more thread-like aspect (*effilée*) whilst its reflexions are much more brilliant and extensive. Under the microscope, in the ordinary feather, the barbule, instead of developing, is seen in many places to have fallen off, whilst the barb or secondary axis is enlarged and coloured, especially at its extreme portions. In the optical feather of the starling the barb has slightly changed, while the barbules, or tertiary axis are much developed both in size and colour."

"The barbs, or branches of the single stem, are in general formed of superimposed segments, more or less persistent, and the barbules constructed on a similar plan, are implanted in the barbs by their basilar segments. This base of the barbule is larger and stronger according to the period, and the nature of the feathers; but internal communications appear always to exist, which may render possible a mingling of pigments between the two axes of optical feathers, and between the same parts of ordinary mixed feathers. All the barbules are, like the barbs, composed of larger or smaller segments, arranged end to end and enveloped in a common epidermis; but as their segmentation has much more importance than that of the barbs, let us see the chief differences which exist between them in spite of their unity of structure."

"1. The lines of demarcation between the segments of optical barbules are much more decided than in ordinary barbules; or, to speak explicitly, separating diaphragms of these different parts are stronger in the former than in the latter. 2. The granular pigment deposits ordinarily diffused in the central nucleus of the segments, are always more abundant and more regularly distributed in the first than in the second. 3. We distinguish around these dark nuclei a layer of parallel or longitudinal fibres, much thicker in the optical barbule than in the ordinary one. 4. The lateral hooklets of the optical barbules are in general more developed in autumn than in spring, and their function

is, as we shall see, different from those of the ordinary barbules."

"Moisture developes each part in proportion to its supply of cortical substance. In the optical feathers the barbules, only augment in diameter, and as each segment swells into a little cylinder, more or less regular, we sometimes see the lateral hooklets swallowed up (*noyés*) in the distended mass, and disappear more or less completely. In the ordinary feather, the barb possesses the most cortical substance and becomes most developed. Possessing all the qualities of the optical barbule, it becomes swollen and coloured, sometimes immersed in its own matter, but usually expelling its useless barbules."

"The ordinary barb becomes much dilated like the optical barbule; but instead of increasing like it, the proportions of its segmentation and separating diaphragms, it loses in its development the character which is associated with the persistence of the barbules in mixed feathers.

"The ordinary barb is simply a fibrous mass. It is at the moment of extreme dilatation of the cortical substance that the pigmentary matter, often extravasated, proceeds to unite and sometimes solder together adjacent barbs, to form certain masses which have a horny appearance, and which we have spoken of in the wax-wing. I have seen several of these accidental solderings in the red frontal feathers of the goldfinch. This enormous dilatation of the barb is only exhibited in those ordinary feathers which are destined to acquire a certain splendour or lustre, and there are many others which exhibit a mean development, and these we call *mixed*."

"*Mixed feathers* comprise all the feathers which undergo little change of form; they constitute a great part of the plumage of ordinary birds: they never exhibit metallic reflexions, are often dull, and though sometimes of a certain lustre, rarely show that brilliance which belongs to the ordinary feathers."

"The barbules of mixed feathers are persistent and in direct communication with the barb that bears them. These barbules dilate and colour themselves at the expense of the barbs, without exhibiting the regular form or the pronounced segmentation of the latter."

"In certain mixed feathers the colouring matter accumulates at the ends of the barbules, which often break at these points, and assume the truncated appearance of optical cylinders. I call these feathers mixed, because they resemble the optical feathers in their mode of development, and the ordinary feather by their mode of colouration."

"Those feathers which owe their colour entirely to the light, whether optical or enamelled, do not change their internal pigmentation, and only acquire their colours by changes

of form; but it is not so with the ordinary or the mixed feathers. They modify their colours either by augmenting the intensity of their original tint, or by replacing an old colour with a new one. In the first case there is a more complete solution of the internal pigments, and in the second an extravasation of the old colouring matter which disappears as an external dust, while a new solution is made of another pigment latent in the barbs. In this case it is rather difficult to obtain a complete solution by operating from without; and I think that since those birds which entirely change the colours of their great wing and tail feathers, modify their little feathers much less, it is probable that a particular grease developed in the body, and reaching the feather internally, may be necessary to a solution of the new pigment, which, as we have seen, is already deposited in the interior of the feather."

"The feathers I have called *enamelled*, comprise all the blue feathers without metallic reflexions, and some of the most brilliant green feathers which are without these reflexions.... These enamelled feathers always exhibit in the interior of their barbs at their birth as well as after a complete moult, large polygonal cells with coloured nuclei. Below the colourless epidermis and on the dorsal or upper face of new feathers, the microscope always shows a layer of elongated vertical cells, and their thickness gradually diminishes in advancing towards the lower surface. These cells constitute what I call the *enamel*.

"This transparent enamel is differently coloured and variable in thickness. Its tint gives the appearance of green or blue, and its thickness gives a greater or less fixity to the colours which often change from the finest blue to the finest green, and sometimes to a tint of delicate yellow. A very thick layer gives the appearance of an opaque colour. In spring the colouration increases, the barbs develope a little, and many barbules disappear, while in the meantime the dark internal pigment gradually dissolves, passing through transitive tints. The enamel only seems to be slightly soluble in the dissolving material in the axis."

M. Fatio gives the following summary of these various actions:—

"1. Of two successive axes the first developes always at the expense of the latter.

"2. In ordinary feathers, properly so called, the secondary axis predominates over the tertiary, and the chief changes take place in the barbs.

"3. In optical feathers, properly so called, the tertiary axis predominates, and the chief modifications are effected in the barbules.

"A. In mixed feathers the barbs undergo some changes, and the persistent barbules are much less modified than in optical feathers.

"B. In enamelled feathers the barbs though optical in pigmentation, swell and colour themselves; the barbules fall."

We must, on a future occasion, return to M. Fatio's important paper.

NEBULAR AND STELLAR SPECTRA.—SOLAR OBSERVATION.—RED STAR.—PLANETS.—OCCULTATION.

BY THE REV. T. W. WEBB, A.M, F.R.A.S.

THE return of the glorious Orion Nebula to our evening skies will always be a source of pleasurable anticipation to the astronomical student: and now that its gaseous composition is fully recognized, the possibility of change will be a fresh inducement to its attentive examination. It must still remain a matter of strange and perplexing mystery, by what agency such changes of figure or intensity can be produced in free space; but it will be admitted that there is less difficulty in conceiving their existence in such a filmy mass, than among an innumerable host of stars, where the presence of mutual gravitation renders derangement of figure almost inconsistent with permanency of existence: and hence the alterations of figure and brightness already recorded or imagined, do not now appear so incredible as they might in earlier days, nor so probably if not certainly due to differences of instruments or climates. We have already on several occasions* referred to the opinions of eminent observers on this head, and we have now to add that renewed investigations have been in active progress on the other side of the Atlantic. A considerable time has elapsed since the late W. C. Bond published, in the *Memoirs of the American Academy*, a finely executed figure of this nebula, with a catalogue of the involved and adjacent stars, which has been thought open to some exception. Otto Struve, in particular, gave it as his opinion in 1857, that the latter was "crowded with errors, and worked without any system," and that the author had "expended more care on the graphical representation of the nebula," without, as it should seem, intending to rate even the diagram very highly. In consequence of these remarks, a careful review was undertaken with the noble instrument previously employed, an achromatic, by Merz,

* See INTELLECTUAL OBSERVER, iv. 258; v. 53; vii. 139; ix. 177.

of 14·95 inches aperture, and 22·5 feet focus, under the direction of G. P. Bond, the worthy successor of his father; and at his death, Feb. 17, 1865, we are informed that he left a MS. containing a thorough and systematic examination of the nebula; a work which continued to occupy his thoughts until a few days previous to his decease.

The Report of Harvard University, dated in the following month, states that "during the winter and early spring of 1864-5, minute observations were made on 59 nights, resulting in the discovery of many new features." The astronomers engaged assert that "it will require a long series of observations to determine whether there are variations of the form of the nebula, or of its light. It will also require many observations to get more precise results about the variability of the stars in the nebula." They think it a question whether the three apparently well-defined groups of stars represented to the naked eye as ι, ϑ, and c *Orionis*, may not be associated with the nebula itself, rather than barely superposed, a point deserving of notice being that many of the stars have nebulous envelopes. It seemed to them highly probable that these three clusters are coincident with three centres of aggregation of nebulosity; and they therefore extended their fresh survey $1\frac{1}{2}°$ N, and as far S of θ, preserving nearly the same limits of RA, 16′ 52″ * each way. Within this area they have determined the places of 1143 stars; the number in H's and Σ's catalogues having been 155, a difference arising in part from the enlarged extent. "It has been found hardly possible to confirm Σ's supposed discovery of variable stars, except in one or two instances. The special difficulty arises from the fact that a bad state of the atmosphere, and the consequent blending of the nebula with small stars in its immediate neighbourhood, renders the latter invisible." They have found 6, not identical with Σ's, which show marked signs of change. They mention among their other results, the tracing of the connection of c, and ι, *Orionis*, with θ, especially the great loop uniting ι with θ, one of the finest features of the whole nebula: the association of the nebulosity with stars by general aggregation round the three clusters—by wisps of nebula attached to certain stars—and by larger numbers of small stars in bright nebulous areas, contrary to the natural optical effect of a brighter ground: the spiral structure of the parts surrounding θ: and the comparative permanency of the form and aspect of the nebula, in contradistinction to the rapid variations supposed by Otto Struve.

These observations, so far as respects the extent and connection of the whole nebulous mass, are in exact correspondence

* There seems to be some mistake in these figures, which I am unable to rectify.

with those of Secchi (Int. Obs. vii. 139); and the possessors of the large silvered specula which are now coming into use will find it an interesting task to ascertain how far they may be able to confirm them. We have already mentioned the full recognition of the gaseous character of this marvellous phenomenon, which cannot be discredited after the accordant results of Huggins and Secchi; but it is gratifying to add that the resolution which has for twenty years been usually ascribed to the reflector of the E. of Rosse, has been disclaimed by its noble maker; his lordship having authorized Mr. Huggins to state "that the matter of the great nebula in Orion, which the prism shows to be gaseous, has not been resolved by his telescope. In some parts of the nebula he observed a large number of exceedingly minute *red* stars. These red stars, however, though apparently connected with the irresolvable blue material of the nebula, yet seem to be distinct from it." This alone was wanted, to set that most curious inquiry definitively at rest. One singular fact, however, may be noted here. The spiral arrangement ascribed to part of the nebulosity by the American observers is also a well-known characteristic of many clusters and groups of stars, and should its existence in the Orion nebula be confirmed, it will form a curious bond of connection between objects of a nature apparently most dissimilar.

An examination of former observations with the great reflector, for which we are indebted to Lord Oxmantown, leads to the important conclusion, that no object to which prismatic investigation has ascribed a gaseous nature has shown a stellar composition in the telescope; the widest discrepancy being that 6 nebulæ giving a gaseous spectrum, had been considered "resolved, or resolvable?" at Parsonstown. The indications of the two very distinct and dissimilar modes of analysis seem therefore to be rapidly and satisfactorily converging. Our readers will be interested in knowing what results the spectroscope of Huggins has given with respect to the objects already enumerated in our list of clusters and nebulæ. The following were all found to exhibit a continuous spectrum: by which is meant, in contradistinction to the insulated bright lines given out by incandescent gases, a spectrum similar to that of such stars as are bright enough for examination, and to that of our own sun.

No. 19 (Int. Obs. vi. 115). 11 M. 4437 Gen. Cat. "The continuous spectra of all the brighter stars were separately visible. When the clockwork of the equatoreal was stopped, an interesting spectacle was presented by the flashing in rapid succession of the linear spectra of the minute stars of the cluster as they passed before the slit. In no part of the

cluster was any trace of bright lines [*i. e.*, the indication of gaseous matter] detected."

No. 20 (Int. Obs. vi. 117). 13 M. 4230 Gen. Cat. "Spectrum ends abruptly in the orange. The light of the brighter part is not uniform; probably it is crossed either by bright lines or by lines of absorption."

No. 25 (Int. Obs. vi. 347). 56 M. 4485 Gen. Cat. "Suspicion of unusual brightness in the middle part of the spectrum."

No. 26 (Int. Obs. vi. 348). 81 M. 1949 Gen. Cat. "The red end of the spectrum wanting or very faint."

No. 27 (Int. Obs. vi. 348). 82 M. 1950 Gen. Cat. "The absence or great faintness of the red portion of the spectrum more marked than in the spectrum of No. 1949."

No. 29 (Int. Obs. viii. 207). 51 M. 3572 Gen. Cat. "A suspicion that some parts of the spectrum [of each of the bright centres] were abnormally bright relatively to the other parts."

Such is the result of prismatic analysis applied to nebulæ and clusters with which we have been made familiar. In a very remarkable and suggestive note the author states that the peculiar appearance of the continuous spectra of some of the nebulæ and clusters has suggested to him, from his first examination, that possibly the luminous points into which the telescope resolves some of them, may not be of the same nature as the true stars. The spectrum of the great nebula in Andromeda and its small companion was recorded in August 1864 as ending abruptly in the orange: and throughout its length not uniform, but evidently crossed, either by lines of absorption, or by bright lines. The same characters, he adds (as we have already seen), have since been found in several of the brighter nebulæ and clusters: it would be possible to explain the absence of the less refrangible rays by absorption through vapour; but the apparently *complete* want of light at that end, and the unequal, mottled appearance of the brighter parts suggest rather a gaseous source; and that the spectrum consists of numerous *bright* lines: they are too faint, however, to admit of a sufficient contraction of the slit to determine this point. But some quite recent observations (June, 1866) not yet complete, appear to support the view that the bright points of some clusters may not be similar in constitution to the sun, or the brighter stars.

Thus it would seem that a new and unsuspected, and most singular field of inquiry is opened to the view of those whose instrumental means admit of its investigation. Such means, indeed, are rare. But if, where they exist, they were pushed to their full capability, much valuable aid might be given to

one whose name must ever stand foremost as the leader of the prismatic analysis of the starry heavens.

Another eminent observer, Secchi, has been diligently prosecuting spectroscopic, or, as he calls them, "spectrometric" inquiries, and has arrived at conclusions differing in some respects from those of Huggins. He has formed a classification of stellar spectra according to distinctly-marked types :—1. That of the bluish-white stars, such as Sirius and Wega, with dark bands in the blue and violet, including nearly one-half of the stars examined :—2. That of the red, or orange stars, with broad zones, such as Betelgeuse and Antares :—3. That of the yellow stars, comprising Capella, Arcturus, etc., marked by fine lines, and resembling the spectrum of our sun. To these are added a type the inverse of the first, found only as yet in γ Cassiopeæ and β Lyræ, and a type peculiar to Orion, distinguished by the intensity of the green. He has also observed in other regions the separate and special predominance of some one type of light. All this is certainly very remarkable, but is only given by himself as the result of a few evenings' work preparatory to a more general and detailed research. Before, however, any fully satisfactory conclusion can be attained, a question will have to be decided as to the nature of many of the bands towards the red end of the solar spectrum, the origin of which, as will be seen in our last number (p. 317), has been largely referred by M. Jansen, of Paris, to the presence of aqueous vapour. As to some of these confessedly delicate and obscure points, further investigation and the labours of many observers are obviously desirable. In such stellar spectra as are crossed by numerous dark bands, a difficulty has been pointed out in ascertaining whether certain intervening luminous spaces may not assume the deceptive aspect of bright and gaseous lines from contrast alone, and here the finest instruments will be required for the decision. As to nebulous material, it is frequently so deficient in luminosity as to elude all known means of analysis. Up to the beginning of the present year Secchi had discovered fourteen very feeble nebulæ which had escaped all former observers; and has found occasionally large spaces where the sky has a milky aspect—the "diffused nebulosity," no doubt, of the Herschels. In the latter case there seems no impossibility in the idea of a vicinity to our own system, which, if it could be estimated, might perhaps surprise us. According to the Roman astronomer the nebula of Orion extends through all the space from ζ southwards to 49 and υ, two 5 mag. stars nearly on the parallel, and somewhat less than 2° apart, forming the bottom of the sword.

One of the most curious observations of this nature, for

which we are indebted to Secchi, relates to a singular convolution of nebulous streaks, RA. 17h. 55m. 18s. DS. 24° 21′ 15″. This is M 8*, or Gen. Cat. 4361. He says (1865, Aug. 8) that this object "se trouve notablement changée. La portion qui divisait ses ovales a disparu, et les ovales ne sont qu'un canal presque continu." The ovals are three included spaces, one entirely, two others comparatively dark, which were, when figured by H. at the Cape (1837, June 27), divided by two streaks of irresolvable haze. There is, indeed, some difficulty in reconciling H.'s description and drawing (semi-inverted, it must be remembered, owing to his front view) with the expressions of Secchi. If I interpret the former aright, his three ovals thrown into one would not form a continuous canal, but an opening bent back at an acute angle, and Secchi seems to be referring to another opening described by H. as a larger and more ill-defined basin distinct from the ovals, and lying in the same straight line with two of them. But whether this conjecture may or may not be right, there seems strong evidence of change. H. observes that the nucleus (which is in the *p* streak) is not stellar, and greatly resembles that of the nebula in Andromeda. Secchi finds that under the spectroscope it exhibits "la raie ordinaire," the usual bright band of gaseous matter. To a suspicion that the great aperture of H.'s reflector (18¼ inches, front view) might reveal interruptions of continuity which Secchi might not perceive, it might be replied that the former was on the other hand unsuccessful in tracing any connection between the principal mass of the Orion nebula and that surrounding the star c. 8 M is not included in the *Bedford Catalogue;* it has now left our evening sky, but may form an interesting object of search in another year, when Sagittarius is in a suitable position.†

SOLAR OBSERVATION.

The "Solar Caps" or dark glasses which have hitherto been adapted to the eye-pieces of telescopes to intercept the heat, and as much as is unnecessary of the light of the sun, are all more or less objectionable as giving a tint to the solar image which might interfere with the real colour, and in some cases perhaps affect the visibility of the more delicate details. A very ingenious contrivance has lately been introduced by G. and S. Merz of Munich to obviate this defect. It is well

* M 1 in the *Astronomische Nachrichten*, from a misreading of the Cape Observations.

† It should have been noticed before that subsequent investigation has shown the relative fixity of the nebulous star 45 $I\frac{1}{2}$ iv. and its companion: so that the suspicion of proper motion advanced in INT. OBS. vii. 188, and derived from earlier measures, must be abandoned.

known that the rays of light, when reflected at a certain angle from a surface of glass, become polarized, and consequently will be either transmitted through, or reflected from, a second similar surface, according to the angle under which the latter receives them. In Merz's new solar eye-piece, 2 pairs of plane glass mirrors (of course, un-silvered), are so arranged as by the rotation of one pair relatively to the other, to intercept at pleasure the whole, or any required part, of the light transmitted through the telescope. Secchi's opinion of this contrivance is decidedly favourable. He says, "your helioscopic polarizing ocular is preferable, because it shows the sun of its true colour; thus films which appeared blue in the ordinary oculars with blue glass, are seen with yours of a rosy hue, the same tint as the protuberances which are seen during eclipses. This is an important fact." It is to be hoped that Mr. Browning or some other skilful optician will turn his attention to this construction in our own country, where the solar phenomena are at present attracting so much notice.

RED STAR.

In an extract from the Memoirs of the Astronomical Society, Vol. iii. p. 187, I find the following statement on the authority of H. "No. 895 (Σ) R.A. 6h. 12m. P.D. 84° 12′ [=D. N. 5° 48′] L full ruby red, or almost blood colour. S fine green, which it loses when the large star is concealed." This object from its double character may possibly have been intentionally omitted from the catalogue of Dr. Schjellerup, of which an abridgment was given in our Sept. number; but it seems likely to repay the search. It will be found near the nose of Monoceros.

PLANETS OF THE MONTH.

Mars is now rapidly approaching the earth, and becoming a telescopic object of much interest. As the opposition, which occurs on Jan. 10, will be somewhat more favourable than the last, as well as those for some years to come, we trust that all available telescopes will be employed in the scrutiny and delineation of his features.

The following remarks, by one so pre-eminent in the art of design as De la Rue, are too valuable not to find a place in relation to this subject. Speaking of the disagreement too frequently observable in astronomical drawings, he says, "These discrepancies no doubt arise in some measure from differences in the aperture and defining power of the telescopes employed; in other instances, much is attributable to the state of the atmosphere at the places of observation. The discordances

arising from the foregoing causes, would, however, not present so many difficulties, were astronomers, as a rule, able to delineate what they see with anything like an approach to accuracy of detail. Much confusion is created by the exaggeration of certain details which happen to strike forcibly the mind of particular observers, who give undue prominence to those features both as regards size and intensity. But astronomers are not responsible for the whole of the difficulties placed in the way of those who undertake the task of reducing observations; the steel-engraver, the lithographer, and the wood-engraver, are answerable for a great share of the confusion engendered by their very free translations of the drawings placed in their hands to be copied."

Mr. Banks, to whom we owe a beautiful series of drawings of this planet in 1864, published in the *Astronomical Register*, remarks that a considerable change will be found in the position of the poles, the N., which was then beyond the limb, coming more and more into sight, while the spots near the equator will be projected further from the centre of the disc, and follow a course much more curved upwards (as seen inverted) so as to render their identification more difficult.

URANUS will be very well situated for observation this month; at the commencement of it lying very near the *sf* edge of the fine cluster near *Propus* (INT. OBS. v. 54) and reaching at its opposition on the 27th, a station between 2° and 3° *sp* ϵ *Geminorum*, a 3 mag. star standing about $\frac{1}{3}$ of the way from Pollux to Aldebaran.

OCCULTATION.

20th. B.A.C. 1526, 6 mag. 5h. 11m. to 5h. 59m.

ON SILK PRODUCED BY DIURNAL LEPIDOPTERA.

BY PHILIP HENRY GOSSE, F.R.S.

THE Rev. D. C. Timins, in his interesting paper *On the Habits of some Lepidopterous Larvæ* (INTELLECTUAL OBSERVER, Nov., 1866) says at p. 255, after describing a silken couch spun across a leaf by the caterpillar of *Charaxes Jasius*—"This is, so far as I know, the only instance of silk being produced by a member of the *diurnal Lepidoptera*."

The expression is too strong; for I need not remind Mr. Timins, I am sure, that the pupæ of the *Vanessadæ* and similar dangling forms hang from a dense conical button of silk spun by the mature caterpillars, while those of the

Papilionidæ and *Pieridæ* have, besides, a thoracic girdle of silk.

But my object in writing is not to correct this little oversight of phrase, but to mention a case very curiously parallel to that recorded by Mr. Timins, of a reposing couch of silk spun by the caterpillar of another showy butterfly, the Tiger Swallow-tail of North America (*Papilio Turnus*). Nearly twenty-seven years ago I thus announced the fact in question in my *Canadian Naturalist*:—

"September 1st. I have lately taken several of the fine green velvety caterpillars of the Tiger Swallow-tail, with violet spots on the body, and two eye-spots. It spins a bed of silk so tightly stretched from one edge of a leaf to the other as to bend it up, so that a section of it would represent a bow, the silk being the string. On this elastic bed the larva reposes, the fore parts of the body drawn in so as to swell out that part, on which the eye-spots are very conspicuous. I have taken it from willow, poplar, and basswood, but chiefly from brown ash. Before it spins its button and suspending girth, it gradually changes colour to a dingy purple."—(*Op. cit.* p. 293.)

ARCHÆOLOGIA.

Discoveries of considerable importance to English history were made in the latter part of the last month in the Cathedral of Rouen, under the care of the well-known Norman antiquary, the Abbé Cochet. It is well known that, as far back as 1838, some well-directed excavations brought to light the original effigy, or statue, of Richard Cœur-de-Lion; the Abbé Cochet has discovered that of Richard's elder brother, Henry Court-Mantel, the turbulent son of Henry II., who, as it is well known, was crowned during his father's life. Contrary to the statement of Montfaucon, who said that Henry's effigy was sculptured in white marble, the material was found to be the hard lias of Créteil, as was the case of that of Richard I. It is unfortunately much mutilated, and the body cracked through the middle. Still it presents many points of great interest. It represents a king of England and Duke of Normandy, and offers a faithful representation of the royal costume of the time. The young prince wears a tunic, or long robe, fastened under the throat by a handsome circular fibula. A girdle, buckled on the loins, is ornamented in its own length with St. Andrew's crosses, and other devices, in a very graceful pattern. The body of the Prince is enveloped in the royal mantle, which is fastened at the shoulders by means of two clasps in the form of quatrefoils. The effigy is without a sword, as was the case in that of his brother

Richard; a broken sceptre is supported on the left arm, and an extremely elegant awmônière is suspended to the girdle. After this discovery the explorations were continued, and other objects of interest were brought to light, by far the most important of which was a leaden coffin, which there can be no doubt was that of John of Lancaster, Duke of Beaufort, the brother of our Henry V., and Regent of France under Henry VI. This had evidently been originally enclosed in a strong coffin of oak. The bones of the great duke were found inside undisturbed; the body had been embalmed with some aromatic substances, the nature of which could not be satisfactorily ascertained, except that mercury had entered largely into them. Drops of mercury which fell from it almost formed a stream. The hair of the head was found perfectly preserved. The hands were crossed over the abdomen. On the breast lay a cross formed by a fillet of a stuff which resembled silk, or fine linen. It was the only object of art found with the body. The Abbé Cochet deserves the greatest praise for the skill and energy he has displayed in carrying out these interesting explorations.

The city of HEREFORD ought to feel flattered in its character for antiquarian interest, for it appears that the three great archæological institutions, the British Archæological Association, the Archæological Institute, and the Cambrian Archæological Association, had each, unknown to the other, chosen Hereford for its place of meeting next year. The Cambrian Association, having been the first to publish its choice, remains in possession, and will hold its meeting in Hereford in the month of August, 1867. The Archæological Institute is understood to have changed its place of meeting to Hull. The British Archæological Association has resolved upon holding its meeting next year at Ludlow, and has elected for its president Sir Charles H. Rouse Boughton, of Downton Hall, near that town. Its week of meeting is to be that beginning on Monday, July 29, and ending on Saturday, August 3. No town in England could, by the beauty of its scenery, and by the multitude of objects of antiquarian interest scattered in and round it, offer so many attractions to the archæologist as Ludlow.

A correspondent at NORHAM has sent us a drawing of an ANCIENT SWORD which was found protruding from alluvial deposit, on the Tweed banks, near that place, after a severe flood, some feet below the surface of the land. The blade, he informs us, is thirty-two inches long; it tapers gradually to a point, and the handle is formed by two lunette cross-bars, the convex sides turned towards each other. It is a very rare type, but Mr. Roach Smith, in his well-known Museum of London antiquities, had one closely resembling it, which was found in the bed of the Thames. He considered it as belonging to a date not older than the thirteenth century, but perhaps even a little later, and this opinion is probably correct.

The excavations at SILCHESTER, on the site of the Roman town (*Calleva*), have been carried on with vigour during the summer and autumn, at the expense of the Duke of Wellington, and under the direction of the Rev. J. G. Joyce, and are becoming every day more interesting. Lines of streets have been already traced, and houses

have been opened, presenting somewhat varied examples of hypocausts, and remains of tesselated pavements, all throwing new light on the condition and manners of the inhabitants of this island during the Roman period. One of the hypocausts recently uncovered is unusual in character: the ground has been first cut into channels radiating from a centre, and afterwards perforated, and faced with tiles, instead of the ordinary arrangement of supporting columns of tiles. The part on which Mr. Joyce is now at work, is supposed, from the appearance of the buildings and from the various objects found in it, to have been the forum of the Roman city. Some of the houses present the appearance of having been altered more than once from their original plan, as though through restorations and adaptations after they had been destroyed. This is not uncommon in the remains of Roman buildings in this island.

An ancient PYRAMID has been recently discovered in the vast plains between New Mexico and California, through which the Rio Colorado flows. It has been originally about 130 feet high, with a platform of a few feet square at the top. It presents the appearance of having at some period suffered from an earthquake. The resemblance of these curious monuments of a primitive Mexican civilization to those of Egypt is very remarkable.

A ROMAN INSCRIPTION has been found on the shore near the now small town of Skinburness, on the coast of Cumberland. Formerly a town of some importance stood at Skinburness, but it was destroyed by a great irruption of the sea so long ago as 1301. It is a fragment of an altar dedicated to the deities addressed on it as MATRIBVS PARCIS. The worship of the *deæ matres*, usually represented as three females seated, and holding fruit, was extensively spread over the north-western provinces of the Roman empire. Here they are identified with the three Parcæ, or Fates. The discovery of this stone would seem to show that the old town of Skinburness had occupied a Roman site. T. W.

PROCEEDINGS OF LEARNED SOCIETIES.

GEOLOGICAL SOCIETY—*November 7.*

The following communications were read:—

ON SOME REMAINS OF LARGE DINOSAURIAN REPTILES FROM THE STORMBERG MOUNTAINS, SOUTH AFRICA. By Professor T. H. Huxley, F.R.S., V.P.G.S.—The specimen more particularly described in this paper is a portion of a right femur, twenty-five and a half inches long, so that the entire femur may be safely assumed to have exceeded thirty inches in length. The peculiar form of the bone, and the characters and position of the trochanters, leave no doubt of the Dinosaurian affinities of the reptile to which it belonged, which must have been comparable in point of size to its near allies, the *Megalosaurus* and the *Iguanodon*. To the former of these it possesses the closest affinity, but differs in the proportional size and

form of its trochanters, and in its much heavier proportions; and the author proposes for it the name *Euskelosaurus Browni*. A portion of the distal end of a femur indicating another genus of large-sized Dinosaurian reptiles was also described, the characters yielded being sufficient to prove that it belongs to another genus than *Euskelosaurus*. The discovery of these remains in the Stormberg rocks was stated to be by no means decisive of their geological relations, as Dinosaurian reptiles lived throughout the Mesozoic period, and may have existed during the Permian; but it is interesting to observe that the Stormberg rocks conformably overlie the Karoo beds, which have yielded the Dicynodonts, and so many other remarkable reptiles and Labyrinthodonts.

Additional Notes on the Grouping of the Rocks of North Devon and West Somerset. By J. Beete Jukes, Esq., M.A., F.R.S., F.G.S.—Commencing with the country around Wiveliscomb, near which place Sir H. De la Beche had indicated an east and west fault of small extension on the maps of the Geological Survey, Mr. Jukes described the rocks of the district reaching from that place north-west to the Brendon Hills, and westwards to Dulverton, including the valley of the Tone, more to the south. From Dulverton he examined the country towards Simonsbath, and then, proceeding to Barnstaple, made traverses from that place to Challacombe and to Bittadon. Similarly, after examining the neighbourhood of Combe Martin, he proceeded along the north coast in an easterly direction, through Countesbury, Porlock, and Dunster, and across the Williton valley to the Quantock Hills. The observations made during these several journeys were given in detail by the author; and the principal conclusions at which he had arrived in consequence were stated to be the following:—(1) There are three areas of old red sandstone in this region, namely, *a*, the Quantock Hills; *b*, the Porlock, Minehead, and Dunster area; and *c*, the Morte Bay and Wiveliscombe ridge. (2) Each of these masses of old red sandstone dips under a great mass of carboniferous slate. (3) The coal-measures, the carboniferous slate, and the old red sandstone of Devon are contemporaneous with the coal-measures, the carboniferous limestone, and the old red sandstone to the north of the Bristol Channel. (4) That if the great fault which the author believes to exist be proved to be absent, his other conclusions will not be altogether vitiated, for the red rocks of Porlock and Dunster may then be taken as the top of the true old red sandstone lying underneath a great thickness of carboniferous slate.

ROYAL MICROSCOPICAL SOCIETY—*Nov.* 14.

A letter was read containing Her Majesty's command that this society, which recently obtained a charter of incorporation, shall be a "Royal Society." Fellows will use the letters F.R.M.S. The bye-laws of the society were revised, and one of them referring to the term of office of the president was suspended with a view to the re-election of Mr. Glaisher, whose term of office would normally expire in February.

Mr. Wenham described a modification of his plan of combining two prisms for binocular vision with high powers, designed by Mr. Ahren ; and Mr. Jabez Hogg exhibited the spring clip described in our *Notes and Memoranda.* Mr. How showed his new student's microscope, which is described in our *Notes and Memoranda.*

NOTES AND MEMORANDA.

Measuring Small intervals and Counting Meteors.—The Rev. N. J. Heineken has sent us two letters on the above subjects. He says that an ordinary spring tape measure—one yard—drawn out and suddenly released, springs back in a quarter of a second, and it may be arrested so as to mark smaller divisions. He says that although the velocity is not strictly uniform, it is near enough for ordinary purposes. By attaching a weight to the tape, and allowing it to spring vertically, he thinks the motion might be regulated. In counting the meteors in the late splendid display, he used "one of Perkins's old pedometers." Each step is registered in this instrument by pulling a string, and Mr. Heineken holds it in one hand, and pulls the string with the other, each time a meteor appeared.

How's New Student's Microscope.—When a number of respectable firms compete in the construction of cheap microscopes, it naturally happens that they distribute the inevitable expenditure in different directions, and it would be impossible to do justice to Messrs. Beck, Pillischer, Baker, Collins, etc., without instituting an elaborate comparison of their several patterns. Mr. How now comes forward with a new pattern, which deserves a high place amongst cheap instruments. The brass-work is very good, the stage has a new arrangement for facilitating its motions, which is one of the best we have seen. The upper part is held to the lower one with springs, offering a convenient resistance, and it can be moved backwards, forwards, up and down, or in slanting directions. Its action resembles that of the magnetic stage in smoothness, etc., but it is far more reliable. A dividing object-glass is supplied with this instrument, giving with ten inches of tube and a Ross A eye-piece, powers of about 45, 100, and 130. The eye-piece employed by Mr. How is of higher power, bringing the magnification to about 200 with the whole combination. Still deeper eye-pieces can be used satisfactorily. The powers are very well finished and corrected. They are of English make, and differ from higher-priced ones in having much smaller angles of aperture. This is a legitimate mode of lessening cost, and small-angled powers being much more easy to manage, and having great penetration, are the best fitted for beginners. All the ordinary objects (excluding lined tests, for which the apertures are not sufficient) are beautifully shown with Mr. How's cheap objectives, and as his student's microscope is made with the universal screw, other objectives may be added when required.

The Wire Spring Clip for Microscopic Objects.—Mr. Curtis (of Mr. Baker's establishment), has improved upon a clip for holding down the covering glass when preparing microscopic objects, which was originally devised by Dr. Maddox. It is made by bending an elastic brass wire, so that it will open and shut like the common letter clip. The cover is pressed down by a small cork, and held in its place while cement is applied and allowed to dry, or Canada balsam allowed to insinuate itself by capillary attraction. Mr. Jabez Hogg informs us that he has found it "extremely useful in mounting algæ, tongues of mollusca, etc., in glycerine jelly, or similar preparations." We can also speak well of it from personal use, and its price per dozen is very small.

The Portable Horizontal Slide Cabinet and Covered Opaque Slide.—These two excellent inventions of Mr. J. Piper, a member of the Old Change Microscopical Society, will, we believe, be sold by the principal makers and dealers in microscopes. The "Cabinet" is a neat box, containing six strong

cardboard trays, lined with white glazed paper. Each tray is divided into six compartments, to hold six slides in a horizontal position. When the box is closed, and the lid held down by an elastic band, each slide is retained safely in its own place, and the whole can travel without injury. As these very excellent cabinets can be sold at a very moderate price, they will, no doubt, come into general use. Mr. Piper's covered slide is exactly what is wanted for opaque objects, which it is desirable to view without the intervention of covering-glass. It consists of a mahogany slide with the usual central cavity, over which a cover is fastened by a small brass pin. When the object is to be viewed, the cover turns on the pin on one side, and can be rotated back again as often as required.

Pseudoscopic Appearance of the Moon.—Most observers are annoyed more or less frequently with the tendency of hollows in the moon to appear in the telescope like elevations, and elevations to look like depressions. Mr. R. Hodgson, in a communication to the *Monthly Notices*, ascribes these effects to the "position of the shadows being the reverse of what we usually see," and he states that by using a reflecting diagonal eye-piece he can change the appearances from reliefs to intaglios or *vice versâ* by revolving the whole eye-piece 180°. We do not feel satisfied with the explanation, as we are accustomed to see shadows in all directions; but we recommend our telescope-using readers to try the experiments Mr. Hodgson suggests.

Peculiar Disengagements of Gas.—M. Babinet states in *Comptes Rendus* that when cold water is poured on the powder of roasted coffee, a considerable quantity of gas is disengaged. This gas, he adds, is probably common air, and equals in volume the mass of coffee employed. If a bottle is half-filled with coffee-powder, and cold water poured in up to the place of the cork, which must be inserted, an explosion takes place, by which the cork is driven out, or the bottle broken. The roasted coffee-powder acts like charcoal in absorbing air, and the water drives it out again.

Secchi on Double Stars.—In *Astronomische Nachrichten*, Father Secchi gives the following positions, measurements, and dates:—For 36 Andromedæ, 1866, 052 P 349°·51 D 1″·314. ζ Cancris AB, 1865, 213 P 245°·30 D 0″·641. Do. 1866, 285 P 234°·62. D 0″·40. ε Bootis 1865, 482 P 324°·70 D 3″·292. η Coronæ 1863, 592 P 23°·26 D 0″·827. Do. 1865, 504 P 26°·26. D 0″·792. Do. 1866, 538 P 33°·13 D 1″·122. μ Bootis 1866, 578 P 180°·30 D 0″·3. ζ Herculis 1865, 55 P 86°± single "Position of a little prominence (?)." ρ′ Libræ (ξ Scorpii) A B he could not well separate in 1864, he now gives them 1866, 519 P 161°·00. D 0·4 ± "well separated."

Human Remains in the Rhine Valley.—Mr. Faudel describes in *Comptes Rendus* the discovery of portions of a human skull at Engisheim, near Colmar, in the formation termed *lehm Alpin*, and in conjunction with bones of the *Elephas primigenius* and *Bos priscus*. He considers these remains to show that man lived in Alsace and in the Upper Valley of the Rhine at the period when the loam (*lehm*) was deposited, and before the country had reached its existing form.

Paper Substitute for Lint.—The Italian *Medical Gazette* states that the Viennese surgeons employ a white blotting-paper, locally known as *papier de soie*, as a cheap and efficient substitute for lint.

A Monster Aerolite.—Marshal Vaillant informs the French Academy that Marshal Bazaine has found a Mexican aerolite, weighing not less than 860 kilogrammes. It is on its way to France, and will figure in the exhibition of 1867.

Ninety-first Planet.—M. Le Verrier informs the French Academy that another planet, the ninety-first, has been discovered at the observatory, Marseilles.

A Light for Photographers.—*Cosmos* states that M. Sayers recommends twenty-four grammes nitrate of potash dried and powdered, seven flowers of sulphur, and seven red sulphurate of arsenic as giving a light with great photographic power.

The Glass Rope of the Hyalonema.—In our last number we mentioned some remarks of Dr. Gray on this subject to which Dr. Bowerbank replies in

Annals of Natural History, and promises shortly a paper to show the "organic unity" of the basal mass of sponge tissue, the spicular axis or rope, and its coriaceous envelope.

Deep Sea Life.—*Annals of Natural History* contains a report by Mr. George Jeffreys on *Dredging among the Hebrides*, in which he states that Professor Sars is of opinion that Dr. Wallich's deep sea star fish is an *Ophiocantha spinulosa*, a well-known Greenland species, found usually from 20 to 190 fathoms depth. He states that Professor Sars has enumerated fifty-two species and distinct varieties of animals found by himself at a depth of 300 fathoms—sponges, rhizopods, actinozoa (anemonies), polyzoa, true mollusks, and worms. The Swedish deep sea dredgings, in the expedition to Spitzbergen (1861), sounded depths of from 6000 to 8400 feet (1000 to 1400 fathoms), and the sea bottom at these depths was covered with a fine greasy-feeling material of a yellowish-brownish or grey colour, rich in diatomaceæ; and polythalamia, annelids, crustacea, and molluscs were found at these depths.

Mr. Pearson's Photomicrographs.—Mr. Pearson has published, through Mr. Frederick J. Cox, a series of photographs of microscopic objects taken with the lime light. Most of those we have seen are exceedingly good; salicine and cinchonidine under polarized light, sections of sarsaparilla, pepper, cherry-tree wood, coal, lime-stone from the Himalayas, and oolite are very beautiful specimens of this ingenious art, excellently displaying the peculiarities of the several objects. A slide of foraminifera seems to be less successful, and the *trichinæ spirales* have not come out with sufficient distinctness. Others, which we have specified, occupy a high place among works of this kind, and show how valuable the photographic process is to give accurate delineations of objects extremely troublesome to draw anything like as well.

New Edition of "The Heavens."—A subscriber calls our attention to Mr. Bentley's advertisement of a new edition of *The Heavens*, with "sixty illustrations," and asks what number the last French edition contains. On referring to our French copy we find 40 plates, and 192 engravings incorporated in the text. We can give no information as to what Mr. Bentley includes in the "sixty" he announces, but we observe that he wants as much money for his edition as the complete French one costs.